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Results of Heat-Treating Bronze Castings

Effects of Annealing Bronze Alloy Castings Studied With the Aid of Microphotographs of Numerous Test Sections—Results Compared With Previous Experiments

By George F Comstock

THE bronze castings ordinarily made, which might be subjected to heat-treatment, are of three kinds: The true bronzes, or those composed chiefly of copper and tin; the so-called manganese bronzes, which are really brasses composed chiefly of copper and zinc; and the aluminum bronzes, or copper-aluminum alloys. The results obtainable by heat-treatment of these three classes of alloys will be described separately in this article.

Considerable has been written, especially by Primrose in England, regarding the improvements possible of attainment by annealing castings of Admiralty gun-metal, or 88-10-2 bronze. The results are noted in "The Practical Heat-Treatment of Admiralty Gun Metal," by H. S. and J. S. G. Primrose, *Journal, British Institute of Metals*, Vol. 9, p. 158. Some experiments made in the writer's laboratory to check this work gave results similar to those found by Primrose, but the improvement was not so marked because the untreated castings were better than those Primrose used. One of the writer's experiments will be described as illustrating the usual results obtained.

FIG. 1—DENDRITIC STRUCTURE OF SMALL CASTING OF GUNMETAL BRONZE, ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE AND MAGNIFIED 20 DIAMETERS

One Experiment Made

A crucible of metal containing 88.5 per cent copper, 9.5 per cent tin and 2 per cent zinc was melted and cast in the form of six cast-to-size tensile test bars, about ½ inch in diameter and 2 inches long between shoulders, with ends ¾ inch in diameter and about 2 inches long beyond the shoulders for gripping in the testing machine. Each bar was fed by a riser joined to it by a thin fin extending the length of the bar. The bars were not machined before testing, but the risers were merely sawed off and the fins smoothed over with a file. With a Leeds and Northrup optical pyrometer the pouring temperature was determined to be 2040 degrees Fahr., which was lower than the true temperature on account of disregarding the unknown factor of emissivity of the molten bronze, but was about in line with other readings that had been found to give good results.

One bar was tested as cast, without heat-treatment, and three bars were heated slowly in an electric muffle furnace to 700 degrees Cent., the temperature recommended by Primrose, and held there for 30 minutes. Then one bar was quenched in water, one was taken out and allowed to cool in the air and one was left to cool in the furnace. The next day another bar was heated to 800 degrees Cent., held there for 30 minutes and cooled slowly in the furnace to 600 degrees Cent. Then the remaining bar was put in and its temperature maintained at 600 degrees Cent. for 30 minutes, after which both were allowed to cool slowly in the furnace. The results of tests on these bars are tabulated in Table I, the yield point meaning the stress causing an elongation under load of 0.01 inch in the gage-length of 2 inches. The hardness tests were made with the standard Brinell machine on cross-sections of the ends of

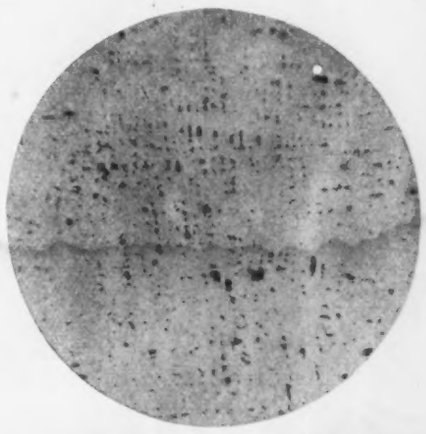


FIG. 2—STRUCTURE OF GUN-METAL BRONZE CASTING AFTER ANNEALING, ETCHED AND MAGNIFIED LIKE FIG. 1, SHOWING SMALL CAVITIES OR GAS INCLUSIONS

FIG. 3—SAME AS FIG. 1 EXCEPT MAGNIFIED 200 DIAMETERS, SHOWING SMALL BRIGHT PATCHES OF EUTECTOID

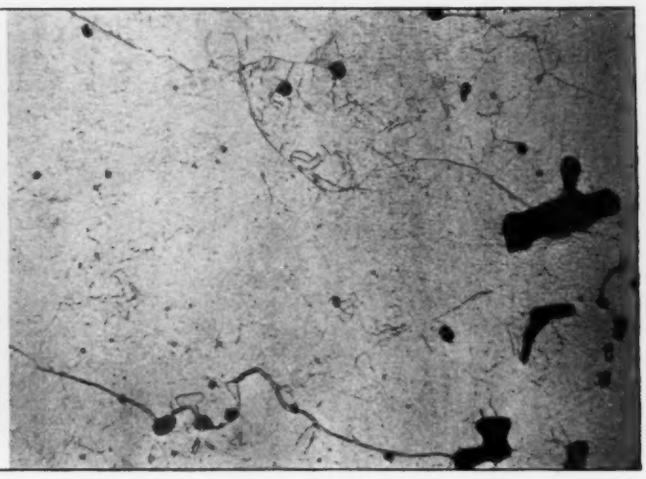


FIG. 4—SAME AS FIG. 2 EXCEPT MAGNIFIED 200 DIAMETERS, SHOWING UNIFORM STRUCTURE

the bars, using a load of 500 kilograms for 30 seconds with a ball of 10 millimeter diameter.

The results in Table I confirm the conclusions of Primrose in the paper mentioned, that annealing at about 700 degrees Cent. benefits this alloy, while quenching in water spoils it. The quenched bar developed numerous cracks all over at an early stage of the testing. Leaving the quenched bar out of consideration, the other heat-treated bars show practically no change in yield point or hardness as compared with the untreated bar, but the other properties were decidedly improved by annealing, especially the elongation which was nearly doubled. Part of this improvement, however, may be due to the fact that the untreated bar had a small flaw. There does not seem to be much difference between the results after heating to 600 or 800 degrees Cent., while 700 degrees Cent. gave worse results. This difference, however, is probably accidental, and in practical use of this process any temperature between 600 and 800 degrees Cent. would doubtless be satisfactory provided it was maintained for at least 30 minutes and followed by very slow cooling.

Examined Under the Microscope

Cross-sections of all the bars were cut at the ends beyond the shoulders, and polished for the microscope. They were etched with ammonia and hydrogen-peroxide, and a few photomicrographs are included to illustrate the typical structures found. The untreated specimen, Figs. 1 and 3, showed the usual distinct cores in the crystals, and small particles of eutectoid scattered between them. The bar heated to 600 degrees Cent. showed very faint traces of the eutectoid, and broader, more diffused cores. Evidently a temperature lower than this would not have much effect on the metal, at least within 30 minutes. The bars heated to 700 degrees Cent. showed no eutectoid and only faint traces of the cores, and the one heated to 800 degrees Cent., Figs. 2 and 4, showed neither eutectoid nor cores. The latter two, however, showed much more numerous cavities in the polished section than the other samples, and it is surprising that the physical results were so good with so many holes in the metal. A possible explanation is that in the metal as cast, the inclusions of gas are in the form of films between the dendritic crystals, and the films are so thin that although affecting the cohesion of the metal adversely, they are not conspicuous on a polished section. When on annealing the crystals change from the dendritic, Fig. 1, to the polygonal form, Fig. 4, these gas films tend to contract owing to the force of surface tension, and form more rounded cavities which are conspicuous on a polished section, but do not interrupt the continuity of the metal as much as the thinner films, and hence allow

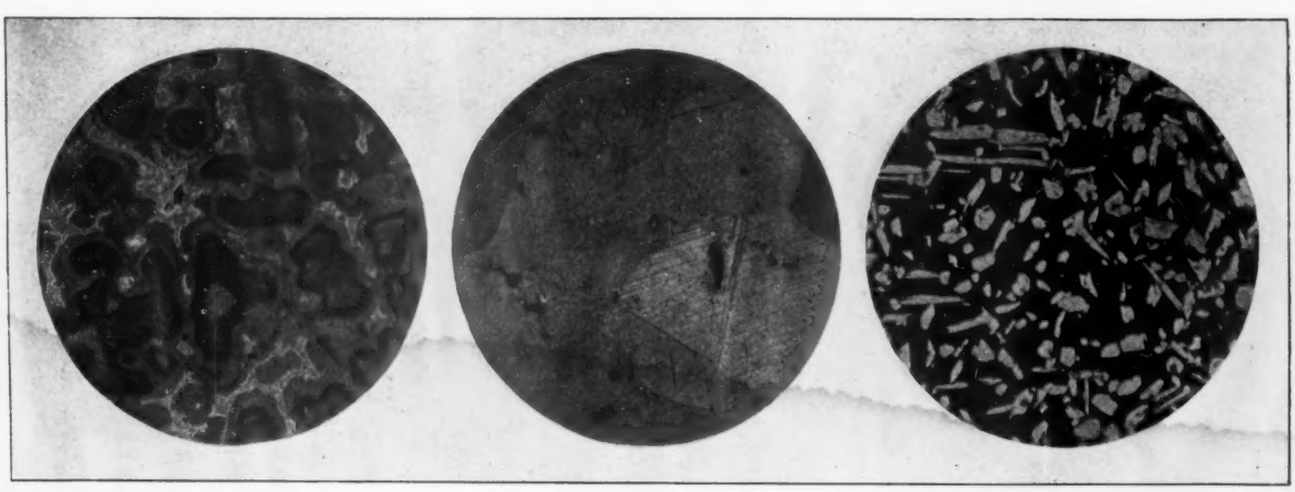


FIG. 5—SECTION OF PHOSPHOR BRONZE GEAR AS CAST, ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE, AND FERRIC CHLORIDE; MAGNIFIED 100 DIAMETERS. SHOWING CORED STRUCTURE AND EUTECTOID

FIG. 6—PHOSPHOR BRONZE GEAR AFTER ANNEALING, ETCHED WITH AMMONIA AND HYDROGEN PEROXIDE, FOLLOWED BY FERRIC CHLORIDE, MAGNIFIED TO SHOW UNIFORM GRANULAR STRUCTURE

FIG. 7—NORMAL STRUCTURE OF GOOD MANGANESE BRONZE, ETCHED WITH FERRIC CHLORIDE AND MAGNIFIED 100 DIAMETERS, SHOWING BRIGHT ALPHA CRYSTALS SEGREGATED OUT IN THE DARK BETA CRYSTALS

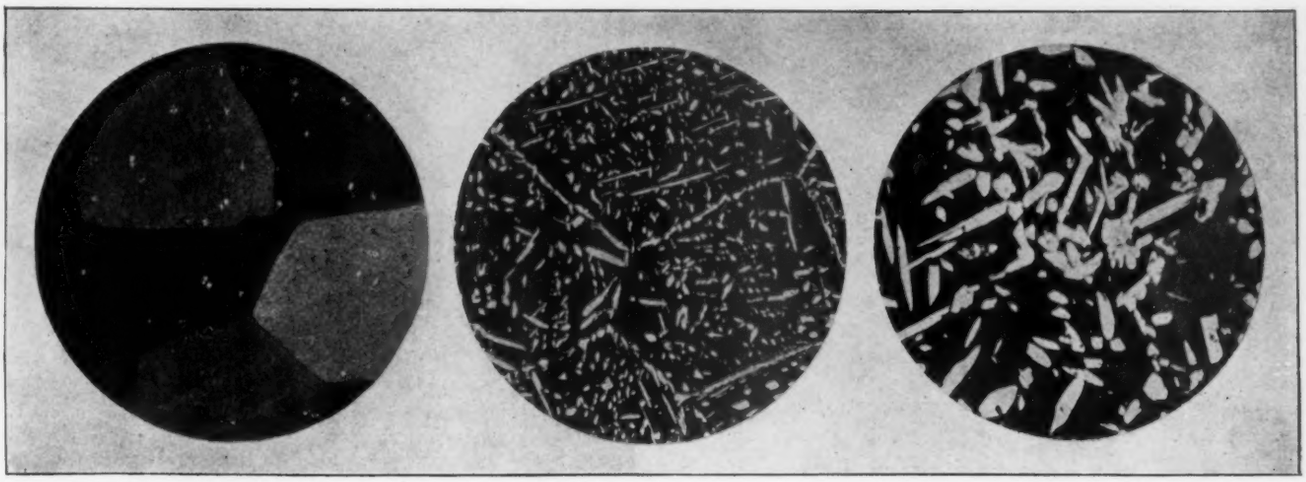


FIG. 8—STRUCTURE OF SAME ALLOY AS IN FIG. 7—AFTER QUENCHING FROM A RED HEAT, ETCHED AND MAGNIFIED IN SAME WAY, SHOWING NO ALPHA, BUT ONLY FINE IRON - ZINC

FIG. 9—FINE UNDEVELOPED ALPHA CRYSTALS IN MANGANESE BRONZE COOLED TOO RAPIDLY AFTER CASTING, ETCHED AND MAGNIFIED LIKE FIG. 7 SAME METAL AS FIG. 10

FIG. 10—NORMAL STRUCTURE WITH PROPER DEVELOPMENT OF ALPHA IN SAME BRONZE SHOWN IN FIG. 9 AFTER ANNEALING ETCHED AND MAGNIFIED IN SAME WAY

a bar to show more strength and elongation when tested.

The microscope did not help to explain the reason for the extreme unsoundness of the bar quenched in water. The structure of this bar was no different from that of the other bars which had been heated to 700 degrees Cent., with the possible exception of the presence of more continuous oxide or gas films at certain spots. Evidently, this alloy cannot stand the strains produced by sudden cooling in water from a red heat, and any idea of trying a double heat-treatment, consisting of quenching and tempering, on copper-tin alloys, therefore, is impractical.

What the Experiment Proves

This experiment shows that gunmetal or 88-10-2 bronze castings can be improved in strength and especially in ductility, by annealing at a red heat or 600 to 800 degrees Cent. for at least 30 minutes, followed by slow cooling, and the structural change produced is the removal of the dendrites or soft cores and of the eutectoid or delta constituent, resulting in a homogeneous polygonal structure. The same change can be produced by annealing any of the ordinary copper-tin alloys. Figs. 5 and 6, for instance, show a phosphor bronze gear casting, containing about 11 per cent tin, before and after annealing. These sections were etched with ferric chloride, darkening the alpha crystals, while Figs. 1 to 4 inclusive, show sections etched only with ammonia and hydrogen peroxide. In Fig. 5 much more eutectoid is seen, on account of the higher tin content, than in Fig. 3, but Fig. 6 shows that practically all the delta was absorbed in the annealing. With higher tin contents, however, this would not always be the case, and some globules of delta would persist in spite of any annealing.

It might be well to note in this connection, that the black areas in Fig. 1, 3 and 5 are not a separate constituent of the structure, but merely the sloping sides of depressions in the polished surfaces, caused by the dissolving of the soft, low-tin cores of the alpha crystals in the etching reagent used. Statements are sometimes made that chill-cast or otherwise quickly cooled copper-tin alloys show a beta constituent as well as alpha and the alpha-delta eutectoid in their microstructures, but these statements are incorrect, as the beta constituent is only found in alloys containing about 12 per cent tin or over, and then only when they are rapidly quenched in water from temperatures above 500 degrees Cent.

Bronze Cast in Chill Mold

When bronze is cast in a chill mold, it solidifies with great rapidity, but the liquid metal heats the chill so much that the rate of cooling below 500 degrees Cent. is never fast enough

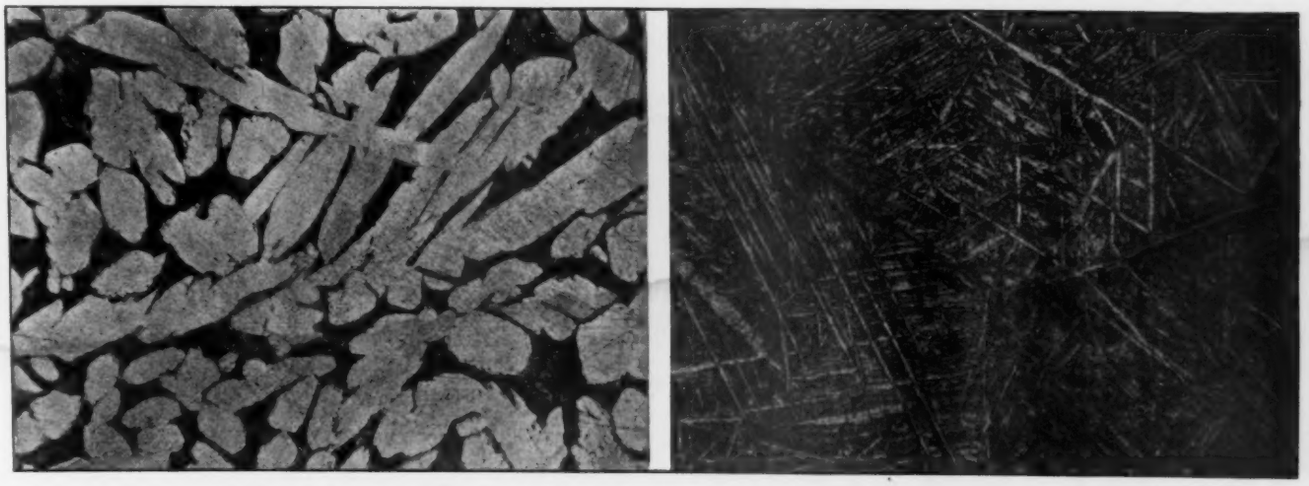


FIG. 11—DUPLEX STRUCTURE OF SMALL CASTING OF 10 PER CENT ALUMINUM BRONZE ETCHED WITH FERRIC CHLORIDE AND MAGNIFIED 200 DIAMETERS

FIG. 12—MARTENSITIC STRUCTURE OF SAME ALLOY SHOWN IN FIG. 11, THOROUGHLY HARDENED BY QUENCHING FROM RED HEAT, ETCHED AND MAGNIFIED IN THE SAME WAY

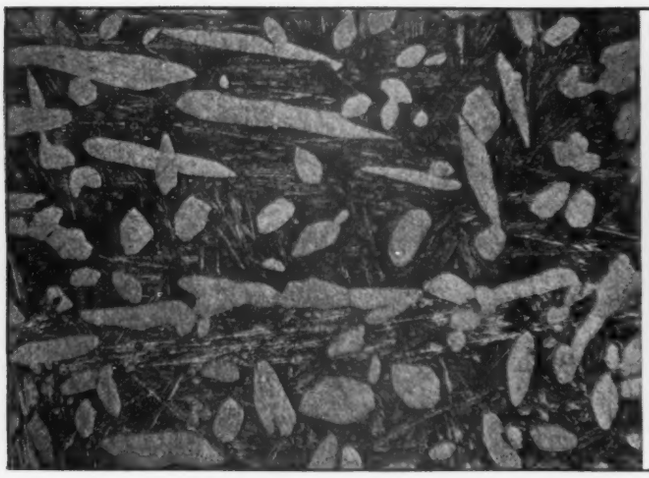


FIG. 13 — INCOMPLETE SOLUTION OF ALPHA CRYSTALS IN SAME ALLOY AS FIG. 12, QUENCHED FROM TOO LOW A TEMPERATURE, ETCHED AND MAGNIFIED IN SAME WAY

FIG. 14—PRECIPITATION OF ALPHA IN SAME ALLOY SHOWN IN FIG. 12, CAUSED BY QUENCHING TOO SLOWLY, ETCHED AND MAGNIFIED IN SAME WAY

to prevent the beta constituent from breaking down into the eutectoid. The reason why rapidly chilled bronze often shows no eutectoid while the same alloy sand-cast does show it, is not because the change from the beta to eutectoid was prevented, but because no beta was formed. In other words, the chilling prevented the development of great differences in composition between the low-tin dendrites and the high-tin ground-mass of the alloy, so that the latter at the chilled part was not high enough in tin to develop any beta which might break down into eutectoid when cooled. In the *Brass World*, March, 1917, Vol. 13, No. 3, Page 76, Fig. 18, the writer showed the appearance of the beta constituent in a quenched bronze containing 13 per cent tin, the beta being darkened a little more than the alpha by ferric chloride, and this appearance is quite different from anything seen in untreated bronze castings.

In the practical application of this annealing process to commercial castings, it should not be expected to make unsound metal give good results when tested after annealing; but if tests are not passed because of segregation, or too great a separation of eutectoid, giving the fracture a gray appearance, then annealing might be expected to improve the results. If the bronze is to be used only as a bearing, however, it would not be a good idea to heat-treat it in this way, for in a good bearing it is necessary to have both hard and soft constituents, so that the presence of the hard eutectoid is desired. When it is removed by annealing, therefore, the bearing qualities of the alloy may be expected to suffer, although the strength and ductility may be improved.

Considering now the copper-zinc alloy known as manganese bronze, very little seems to have been published regarding the possibilities for heat-treatment of castings of this alloy. The writer has made a few experiments along this line, however, which may be of interest to casters of this alloy, who have rigid tensile specifications to meet. The tests noted here were made on bars of the usual size and shape machined from keel-blocks except where noted, and the yield point was taken in all cases as the stress producing a deformation of 0.01 inch in the gage-length of 2 inches.

The effect of quenching marganese bronze in water from a red heat is to fill the metal with invisible cracks, just as is the case with true bronzes, and these cracks ruin the tensile properties of the alloy. For instance, two bars from the same heat gave results as follows:

	Yield point, lbs. per sq. in.	Tensile strength, lbs. per sq. in.	Elongation, per cent	Reduction of area, per cent
As cast	26,400	66,000	40.0	43.6
Quenched in water from 800 deg. Cent..	38,500	64,300	4.0	7.5

Other good bars quenched from 760 to 820 degrees Cent. had their strengths cut in half and their elongations reduced to nothing. The change in microstructure produced by quenching is illustrated in Figs. 7 and 8, the

FIG. 15—FINE STRUCTURE RESULTING FROM ANNEALING QUENCHED ALLOY LIKE FIG. 12 AT 575 DEGREES CENT., ETCHED AND MAGNIFIED IN SAME WAY

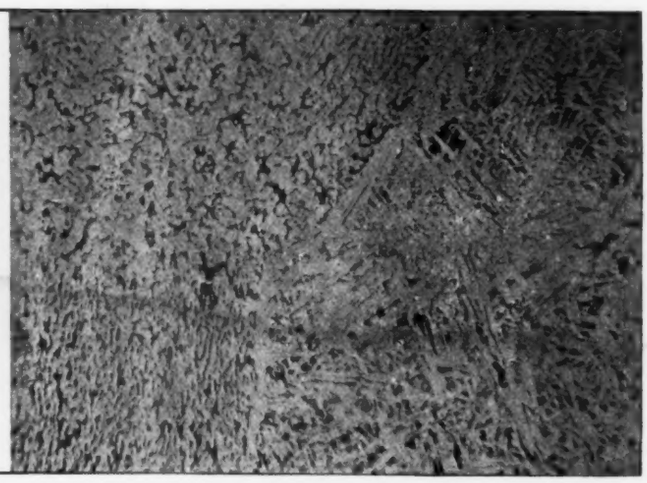


FIG. 16—SLIGHTLY COARSER STRUCTURE PRODUCED AS IN FIG. 15, EXCEPT THAT THE ANNEALING TEMPERATURE WAS 650 DEGREES CENT., ETCHED AND MAGNIFIED IN SAME WAY

latter showing all the alpha crystals to have been absorbed by the beta, leaving only the fine blue iron-zinc crystals scattered through the large beta grains. It is not the absence of alpha crystals, however, which spoils the properties of the quenched alloy, because a manganese bronze made a little too high in zinc showed exactly the same structure as Fig. 8, even after annealing, and when tested showed 85,800 pounds per square inch tensile strength and 22 per cent elongation in a cast-to-size bar. The sudden contraction of the glowing metal in water seems to cause strains that it cannot stand without rupture.

This alloy does not have a dendritic structure like the tin-bronzes when cast, so that there are no soft cores or eutectoid which may be removed by annealing. But the proportions of the alpha and beta crystals of which it is composed may be varied somewhat by the heat-treatment, and since these two constituents have slightly different properties, a corresponding difference may be caused in the alloy by such treatment. The tests in Table II illustrate these slight differences.

The microstructure of heat B before and after annealing is shown by Figs. 9 and 10, respectively, which illustrate plainly the difference in development of the alpha crystals caused by the different rates of cooling. The test results do not show great differences from the heat-treatment, but still it is indicated that if a manganese bronze casting is too low in elongation, it might be improved by annealing and slow cooling; and if it is too low in yield point or strength, with plenty of elongation, annealing followed by rapid air-cooling might be beneficial. The annealing and slow cooling merely permit the full development of the alpha crystals compatible with the zinc content, thus increasing softness and ductility, while rapid cooling checks their development and increases hardness and strength. Thus, manganese bronze castings should cool slowly in their molds if the best elongation is desired, and should not be shaken-out of the sand hot unless stiffness is desired rather than ductility. It should be realized, however, that the effect of annealing on manganese bronze is small compared to the very important effect of variation in the zinc content, which is difficult to control on account of the uncertain amount of volatilization of zinc during melting and pouring.

Aluminum bronze is far more susceptible to improvement by heat-treatment than manganese bronze, and when it contains approximately 10 per cent of aluminum it may be hardened and tempered like steel. The alloys of the copper-aluminum series containing less than about 8.5 per cent aluminum, which consist wholly of alpha crystals, are not appreciably affected by heat-treatment, so that the following remarks should be considered as applying only to alloys with from 8.5 to 11 per cent aluminum, above which the metal becomes too brittle to be generally useful. The experiments quoted herewith were performed on the common alloy containing about 10 per cent aluminum with 1 per cent of iron and the balance copper, having a duplex structure as illustrated in Fig. 11. The light constituent here is the alpha solid solution, and the dark part, called beta, is unstable at ordinary temperatures and is the constituent which is affected by heat-treatment.

Several test bars were cast from the same pot of metal as the one illustrated in Fig. 11 and were cast to the usual size and shape and not machined before testing. One of them was tested as cast, and another after quenching in water from 850 degrees Cent., with the following results:

	—Bar—	
	Untreated	Quenched
Proportional limit, lbs. per sq. in.	19,800	39,800
Tensile strength, lbs. per sq. in.	74,000	97,400
Elongation, per cent	19.5	1.0
Reduction of area, per cent	23.7	0.0
Brinell hardness	100	240

The proportional limit mentioned was obtained from an autographic load-deformation curve, by noting the stress corresponding to the point of departure of this curve from a straight line. The yield point of the untreated alloy, if determined as it was with the other bronzes previously mentioned, it would have been about 23,000 pounds per square inch, and that of the quenched bar correspondingly higher.

The remarkable hardening resulting from this treatment has been corroborated many times on different melts of this alloy, and the foregoing table is typical of the results always obtained when the quenching has been properly done. The structure that should be produced is shown in Fig. 12, where the alpha crystals are absent, having been absorbed by the beta at the temperature of the furnace and prevented from reappearing by the rapidity of the cooling in water. The acicular or needle-like structure shown by the beta is typical of this quenched alloy, and, like the markings of martensite in steel, is probably the result of quenching strains that cause the etching reagent to have a different effect along the lines of greatest strain.

Quenching this alloy from too low

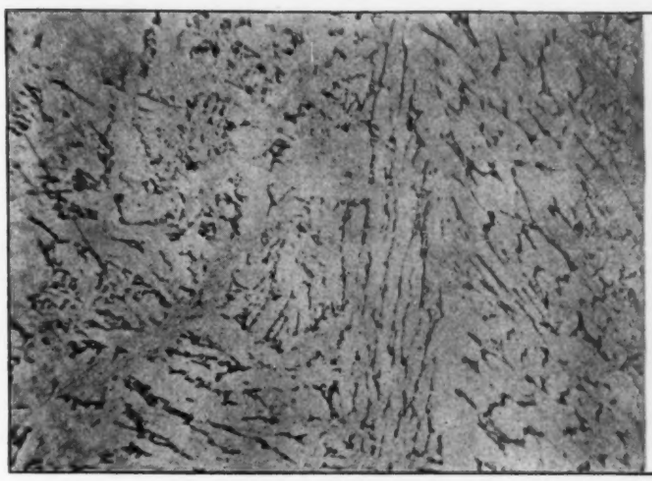


FIG. 17—STRUCTURE OF LARGE CASTING OF 10 PER CENT ALUMINUM BRONZE, QUENCHED AND ANNEALED LIKE SMALL CASTING ILLUSTRATED BY FIG. 16, SHOWING A SOMEWHAT COARSER STRUCTURE, ETCHED AND MAGNIFIED IN SAME WAY

FIG. 18—STRUCTURE OF LARGE CASTING OF 10 PER CENT ALUMINUM BRONZE COOLED NATURALLY IN SAND, SHOWING CHANGE OF DARK BETA CONSTITUENT INTO GRAY LAMELLAR EUTECTOID, ETCHED WITH FERRIC CHLORIDE AND MAGNIFIED 200 DIAMETERS

Table I

Physical Tests of Bars, With and Without Heat-Treatment

Bar heated to, deg., Cent.	Cooled in	Yield point, lbs. per sq. in.	Tensile strength, lbs. per sq. in.	Elongation, per cent	Reduction of area, per cent	Hardness	Remarks
Not heated	.....	22,100	43,400	26.5	23.7	67	*
700	.....Water	18,200	18,700	7.5	6.7	66	†
700	.....Air	21,600	44,600	41.5	33.5	67	..
700	.....Furnace	20,700	45,400	41.5	34.3	68	..
600	.....Furnace	21,800	48,500	50.5	46.2	71	..
800	.....Furnace	21,000	48,200	58.0	38.0	67	..

*Small flaw.
†Unsound.

Table II

Physical Tests of Manganese Bronze, Before and After Heat-Treatment

Heat-treatment	Yield point lbs. per	Tensile strength lbs. per	Elongation per	Reduction of area per
A As cast	32,600	77,600	21.0	21.2
A Annealed at 580 degrees Cent. cooled in furnace.....	28,600	75,200	23.0	21.9
B As cast	28,800	79,400	23.0	23.0
B Annealed at 790 degrees Cent. cooled in furnace.....	28,400	77,600	28.5	25.5
C As cast	28,600	71,000	33.0	28.0
C Annealed at 820 degrees Cent. cooled quickly in air.....	32,100	77,300	31.0	28.2

a temperature results in incomplete hardening, and Fig. 13 shows the structure of a bar treated in this way. The alpha crystals are seen not to have been entirely absorbed, although the beta constituent shows the acicular markings caused by quenching. Quenching too slowly, or cooling the alloy too much in the air between the furnace and the water, also gives incomplete hardening, as illustrated in Fig. 14, where considerable alpha is seen to have separated out along the cleavage planes and grain boundaries of the quenched beta constituent. Speed in quenching is more necessary with this alloy than with steel, because the scale formed on the bronze is not sufficient to prevent much heat loss between the furnace and the water, and the alpha will separate out very rapidly if the cooling is at all gradual.

The quenching bath for aluminum bronze should be convenient to the heating furnace, and preferably should be equipped with a generous supply of running water, or be large enough to allow the rapid movement of the bronze in the water during quenching, so that no steam bubbles are allowed to interfere with the most rapid possible cooling.

Although the quenched aluminum bronze has a much improved stiffness, strength, and hardness, as compared with an untreated casting, it is very deficient in ductility. This can be remedied by a slight tempering, or low-temperature annealing, which increases the elongation and reduction of area and also, strangely enough, the proportional limit, while decreasing the tensile strength slightly and the hardness considerably. These changes can be controlled by the temperature used in annealing, a low temperature giving only a slight change from the quenched condition, and a higher temperature giving results that approach those typical of the cast, untreated alloy. Some test results illustrating this are given in Table III, all having been obtained from cast-to-size bars of the same heat as the bars previously described, quenched in water from 850 degrees Cent. and slowly cooled after second heating.

The time of holding at the temperature given in Table III was from 15 to 30 minutes, and it was found that cooling in the furnace gave a better combination of results than cooling outside in the air. The temperature generally adopted for this treatment was around 620 degrees Cent., but temperatures from 575 to 650 degrees Cent. are fairly suitable. The microstructure produced by the 575 degrees anneal is shown in Fig. 15, and consists of very fine alpha crystals with small dots of delta between them. In other words, the beta constituent is allowed to break down completely into alpha and delta, but the temperature is kept low enough and the time of treatment short enough so that the crystals remain fine instead of combining into their original coarse size. Fig. 16 shows the slightly coarser grain produced in annealing at 650 degrees Cent. after quenching, this bar having more elongation but a lower proportional limit than the one illustrated in Fig. 15.

When applied to larger castings of 10 per cent aluminum bronze this method of double heat-treatment gives a similar improvement to that just described in stiffness and strength, but the results of course are not as good as those obtained from small bars. The following results, although from different heats, will illustrate the effect of the treatment on regular castings of fairly large size:

	Bar from large casting Untreated	Bar from large casting Double heat-treated
Proportional limit, lbs. per sq. in.	18,000	39,700
Tensile strength, lbs. per sq. in.	57,300	78,200
Elongation, per cent.....	12.5	9.5
Reduction of area, per cent....	15.0	15.0

The microstructure of this heat-treated casting is shown in Fig. 17, and is seen to be of the same type as that of the small bars similarly treated, Figs. 15 and 16, but somewhat coarser on account of the necessarily slower cooling of the larger mass of metal in both treatments. However, it is decidedly finer than the usual structure of a large casting of this alloy in the untreated state, illustrated in Fig. 18, about which more will be said later.

Although slight annealing of quenched 10 per cent aluminum bronze gives such excellent properties as have been described, too long annealing of this material, or any annealing at all of the unquenched alloy is detrimental to its ductility as well as its strength. When the cast alloy, whose structure is illustrated in Fig. 11, is cooled too slowly in the sand as in a large casting, or is annealed and slowly cooled, the alpha crystals increase in size, and the beta constituent assumes its stable form which is a eutectoid of alpha and delta, like pearlite in steel. Fig. 18 shows a casting in which this change has occurred though not completely, as the black parts represent beta in the unstable, air-cooled state, while the finely speckled parts are the stable eutectoid. This change makes the alloy brittle in proportion to its completeness, and the casting represented

(*Concluded on page 205*)

Table III

Physical Tests of Aluminum Bronze After Heat-Treatment

Temperature of second heating, degrees Cent.	Proportional limit lbs. per sq. in.	Tensile strength, lbs. per sq. in.	Elongation, per cent	Reduction of area, per cent	Brinell hardness
500	56,700	96,100	5.5	9.1	158
575	46,100	94,100	8.0	11.2	143
610	43,400	96,700	10.5	12.6	140
650	39,300	91,200	14.0	18.5	143
700	23,400	80,000	23.0	21.7	104

Scientists Co-operate With British Foundrymen

Great Britain's Controller of Castings Submits Interesting Discussion of Article in February Issue of The Foundry

ONE of the strong characteristics of British foundrymen is their willingness to dig into the scientific fundamentals of their industry in order to reach practical results. In other words, there is co-operation in Great Britain between foundrymen and scientists. This is clearly brought out in the following communication from G. Ernest Wells, foundry manager, Edgar Allen & Co., Ltd., Sheffield, England, in which he tells how the sand problem is being attacked from a scientific standpoint.

During the war, Mr. Wells was director of foundry production for the ministry of munitions, and as such he became intimately familiar with the castings industry of the British Isles as a whole. His communication, which is a discussion of the article on British foundry practice published in the February issue of THE FOUNDRY, pages 53-57, is therefore unusually important and authoritative. The modifications he suggests with reference to certain statements in the original article are gladly accepted by the author, and his additional comments contain facts with which progressive American foundrymen should be familiar. Mr. Wells' letter in full is as follows:

Quality a First Consideration

I have read, with particular interest, the article on British foundries, by Mr. H. Cole Estep. Generally, it is excellent, and you are to be congratulated on the way in which you have summed up the position during the short time at your disposal. I agree entirely with your conclusions that the per-man output of our foundries is low as compared with yours, but I feel that we are going ahead on the right lines when we put quality first.

As you correctly observe, the average Englishman is slow to move in the direction of a change, but I am convinced that even in English steel foundries, I could have shown you individual cases of quantity-production which would have pleased you. There is no doubt that the germ of quantity-production is already here, but we intend to guide it so that quality production does not suffer as a result. We are hoping to so shape the education of our apprentices that we shall, in the future, possess the most highly skilled operators, as we feel that, other conditions being equal, the most highly trained man will produce the best work, and, given the will to produce, there is no reason why he should turn out any less amount than the unskilled man whose only interest is in the figure of his pay ticket at the end of the week.

I am more than sorry that a trip to your country which I had fixed up for the autumn of 1913 had to be abandoned owing to labor troubles on this side. I am thus unable to discuss your methods as you can discuss ours, but I hope to visit you, in order to see for myself, at the first opportunity. Professor P. G. H. Boswell, whom I was instrumental in sending to the United States last autumn, speaks in the most glowing terms of the reception accorded to him, and he agrees, that, as far as output is concerned, you have us beaten hollow. He agrees with me, however, that there is still something to be said for the more cautious methods adopted in this country.

Plenty of Converter Castings

Referring for a moment to your article (page 57) I notice you state "Relatively few converter castings are produced." I don't know how you gathered this impression, as it is neither true of Sheffield as a district nor of this country as a whole. I cannot give you perfectly accurate figures as some foundries run two processes and I only have figures of total output.

Taking the returns for October, 1918, however, and analyzing them with every care, I find that out of a total weekly production during that month of 3512 tons, 1587 tons were from the converter, 1037 tons from the Siemens (open-hearth) furnace and 538 tons from the electric furnace. The remaining 350 tons were produced by small jobbing crucible furnaces, and the vast majority of the open-hearth output is acid steel, the amount turned out from the basic open-hearth being almost negligible.

In regard to mechanical fettling, or sand blasting, the steel foundries are generally much better equipped than you would seem to believe and further progress in that direction was only held up during the war period by the impossibility of getting the shot-blast plants in sufficient quantity. Jarring machines are becoming rapidly much more common, although for certain classes of intricate work it is more than probable that the hydraulic squeezer machine will make good in the future. It is this machine which has done so well in Belgium, northern France, and Switzerland, which countries, in my opinion, produced the cleanest and most uniform small steel castings procurable before the war. One great advantage these countries possess is their comparatively abundant supply of natural molding sands.

We, in this country, have similar sands, although not quite so good or so consistent and, unfortunately, in quantities which at the present rate of consumption, will disappear in a comparatively short period. In that case we shall be forced to import foreign sands as before the war, or alternatively to use an artificially bonded sand, as is the practice in your country. The latter course necessitates an infinitely greater knowledge of sands and methods of mixing than we possess at the present time, but, with the hearty interest our scientists are now taking in foundry problems, I do not despair of finding a satisfactory solution of the difficulty.

On the other hand, to attempt to make artificially and in a very short space of time, a sand identical with one which it has taken nature millions of years to produce, is in itself something of a proposition.

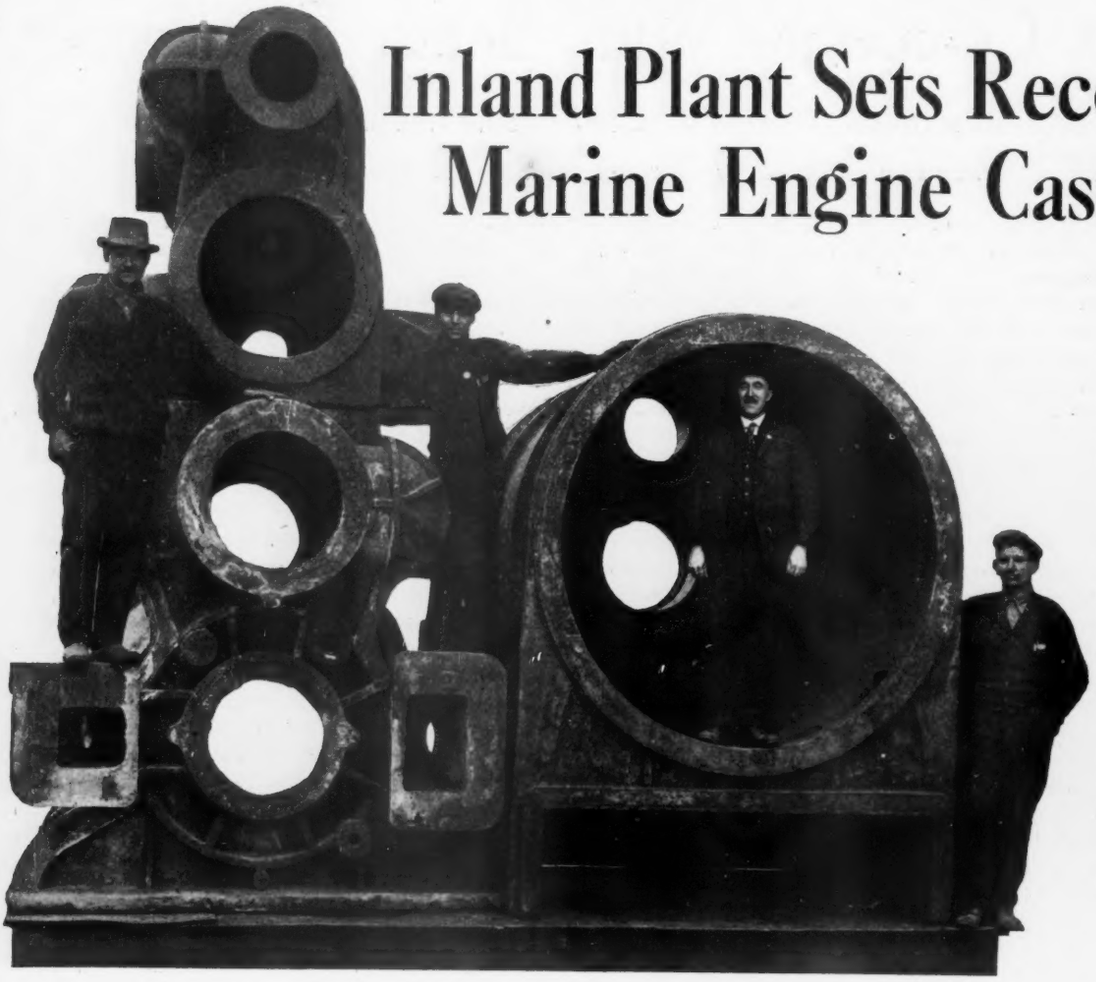
I heartily reciprocate the sentiments you express in the penultimate paragraph of your letter, and I hope that foundrymen in your great country will believe that while we want and hope to beat them, we are at all times actuated in that feeling by the sporting instinct, and if we can't win, we are prepared to take our licking and to try once more.

Elect New Officers

In view of the recent resignation of Alfred S. Ayres, secretary and purchasing agent of the Sanitary Co. of America, Linfield, Pa., a number of changes in the personnel have been effected. B. W. Frederick, formerly affiliated with the Keystone Supply & Mfg. Co., Philadelphia, has been elected secretary and will assist in the management of the business. Grant P. Bechtel has been elected assistant treasurer, and L. A. Shiffert has been appointed assistant secretary and purchasing agent.

Inland Plant Sets Record on Marine Engine Castings

By D M Avey



TO ONE FAMILIAR WITH FOUNDRY PRACTICE AND MORE PARTICULARLY THAT DEVOTED TO HEAVY MARINE ENGINE CASTINGS, IT SEEMS ALMOST INCREDIBLE THAT THE ILLUSTRATION SHOWS A SINGLE DAY'S OUTPUT. THOSE RESPONSIBLE FOR THIS RECORD ARE, LEFT TO RIGHT, FRED BARENDT, FOREMAN; TIMOTHY MURPHY, ASSISTANT FOREMAN; JAMES A. MURPHY, SUPERINTENDENT, AND BERT McGINNIS, CORE SHOP FOREMAN

IF medals were awarded for industrial daring there is at least one builder of marine engines who has earned numerous citations. Sheer audacity is the only term which fitly characterizes the successful organization and production plan which this company originated and operated. It entered upon a class of work similar, in general character, to that which the shop previously had handled, but so different in detail as to constitute a new field. It departed from the blazed trail of previous experience and applied its former knowledge only as a basis to lay a course. The attainments rest solely upon a personal quality—engineering daring. When the roll was called of those plants equipped to manufacture steam power units for the Emergency Fleet corporation, the Hooven, Owen, Rentschler Co., Hamilton, O., builder of corliss type engines, offered its services. Plans for a type of engine then most desired were sent to the plant for inspection. The foundry superintendent, James A. Murphy, examined them and on his assurance that the large castings needed could be produced on schedule, the company offered to build a complete engine per week.

The proposal based upon this estimate was forwarded in due form. Official wisdom received the preposterous proposition with politely elevated eyebrows. Impossible! Did not the gentleman in the foundry know that the intermediate cylinder of this engine alone, required six weeks to mold and cast?

In the interval, the plans again had been considered and studied. Mr. Murphy begged to offer an amendment, superseding his first judgment of the undertaking. He would make castings for *two* complete units a week. Official sparring and moves by which a contract finally was placed may be passed. The contest of wits staged on the molding floor with previous time records as opponents is much more interesting. The foundry not only met the need for two engines a week, but bettered the schedule and turned out the heavy castings for a *complete engine per day*. The nerve and genius of the foundry's directing head was backed by loyalty and

FIG. 1—THE DRAG, TWO CHEEKS AND COPE ASSEMBLED AND CLAMPED FOR POURING THE LOW-PRESSURE AND INTERMEDIATE CYLINDERS—THE SAME METHOD IS USED FOR THE HIGH

co-operation from the 450 employes. No labor troubles occurred to complicate the problem and the willing, faithful work of the shop force was a potent factor in making this record possible.

Established practice recommended that large cylinders be molded head down. This foundry made them head up. Blacking of a large mold such as was used for practically each of the engine castings ordinarily requires a half-day's time. By using a spray nozzle, invented by Mr. Murphy, this time was cut down to a half hour or less. Drying large molds with charcoal fires sometimes takes days. An ingenious utilization of waste space allowed an entire large cylinder mold to be dried overnight.

Assembling cores in the molds on this class of work sometimes required several days, and the complete building-up of the mold sections with all the cores for a large cylinder often took several weeks. In the Hamilton foundry, cores were bunched on a common arbor; larger cores were grouped and baked together, and assembling gangs put together an entire cylinder mold in less than eight hours.

All these time-saving innovations required genius and self-confidence. To attempt even the rigs needed to handle the marine engine work was daring in the face of the novelty of the undertaking and the doubt as to its continuation and success. But the work has been handled well.

This moderate-sized foundry has produced heavy castings for an average of three complete engines per week which the company's own machine shops have finished and built. In addition, the foundry has shipped castings to Atlantic, Pacific, Gulf and Great Lakes shipyards to be machined. The 1400-horsepower engine, first specified for the wooden ships was followed by 850-horsepower units designed for tugboat and light steamer service. The engine for which castings are being made in quantity at present is 2800-horsepower. The illustration at the head of this article conveys an idea of the size of this engine. The high, intermediate and low-pressure castings weigh about 21,200, 21,300 and 22,900 pounds, respectively.

The start upon the work was made in October, 1917. Although the initial order for 1400-horsepower triple expansion engines first placed did not warrant a great expenditure for equipment, a layout was devised which has

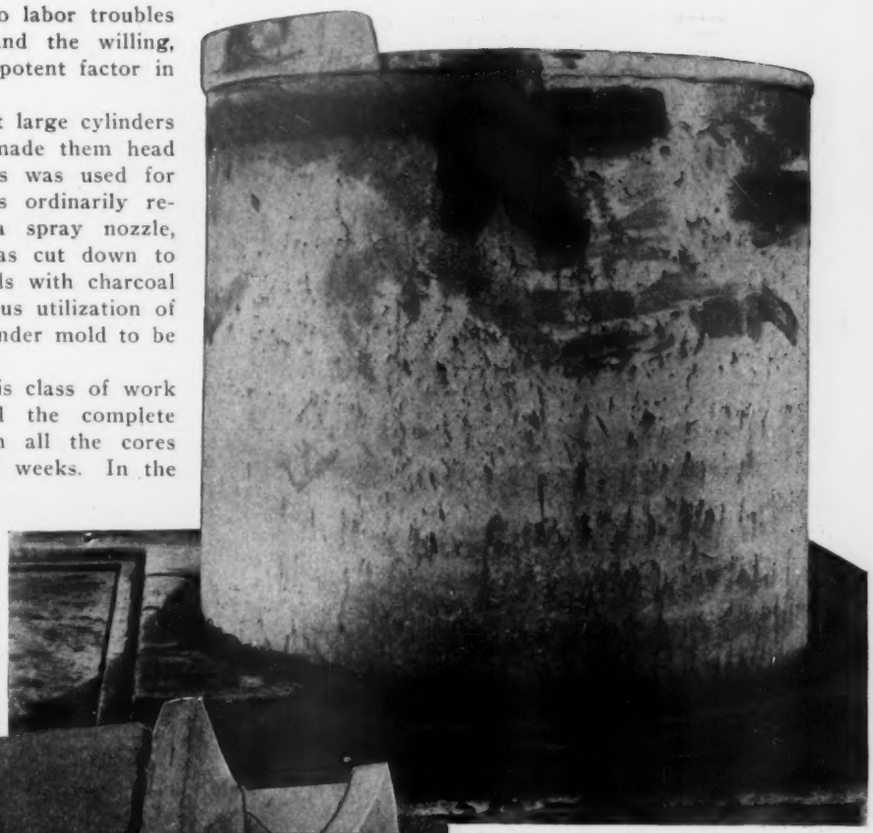
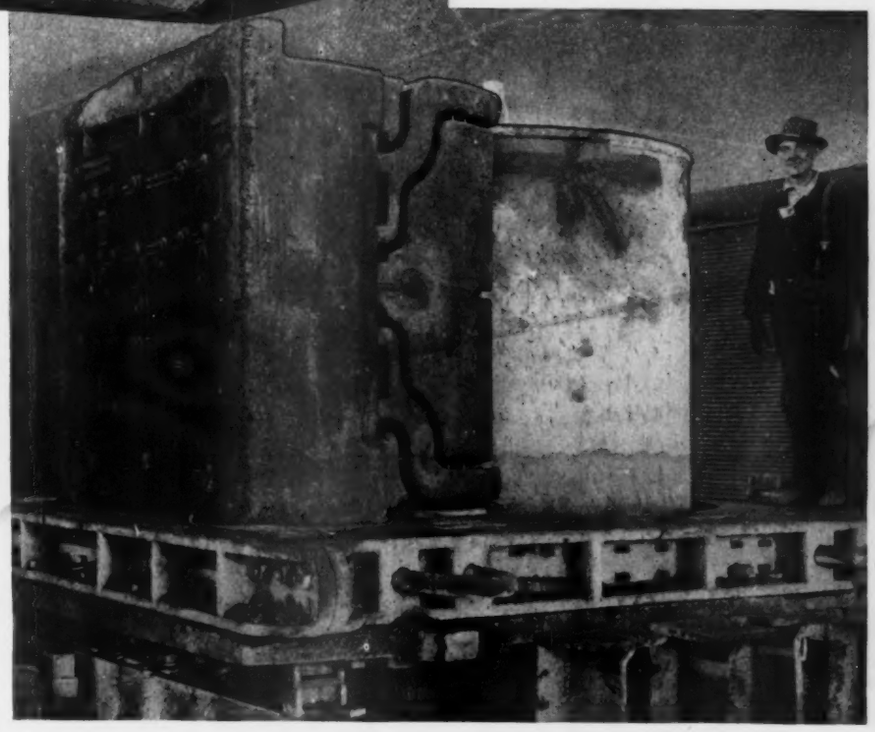


FIG. 2 — TOP—THIS SHOWS A COMPLETED LOW-PRESSURE DRAG AND BARREL CORE AFTER IT COMES FROM THE OVEN. FIG. 3—AT THE LEFT IS ILLUSTRATED THE VALVE CHAMBER CORE AS IT IS MOLDED AND AFTER IT HAS BEEN BAKED. FIG. 4—BOTTOM—THIS ILLUSTRATION INDICATES THE MANNER OF ASSEMBLING THE VALVE-CHAMBER CORE ON THE DRAG, AFTER WHICH THE HOLES ARE FILLED AND THE DRAG IS AGAIN RETURNED TO THE CORE OVEN TO BE BAKED OVER NIGHT



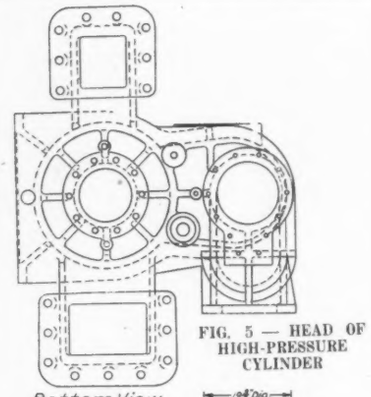


FIG. 5 — HEAD OF HIGH-PRESSURE CYLINDER

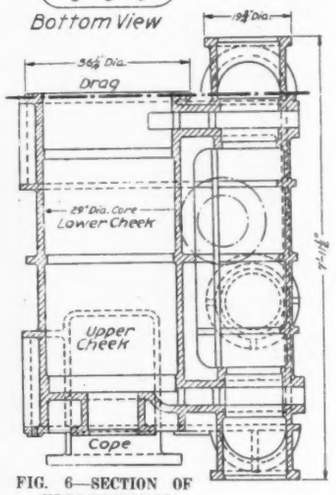


FIG. 6—SECTION OF HIGH-PRESSURE

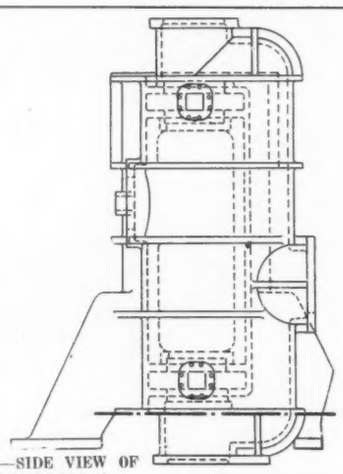


FIG. 7—SIDE VIEW OF HIGH-PRESSURE

cylinders had been lost in the foundry. One resulted from a damp mold and the other from the molten metal entering a vent. The loss, including all those rejected for any reason on inspection, has been less than 2 per cent.

The foundry management at this plant believes in adequate rigging and accurately made equipment. The flasks for the cylinder job were built in the foundry to conform to the ideas of the superintendent. Strength is secured through amply flanged sides, bolted together at the four corners. Steel loops for engaging the crane hooks are cast into the opposite ends, and the continuation of the sides and the end flange connections are rounded to form a cradle for rolling-over the flasks. This lessens the jar to the mold when the flask is rolled over. As may be noted from Fig. 1, the sides and ends are bolted rigidly together. Furthermore, to insure against shifting at the corners, a register is provided between the sides and the connecting flanges of the ends. One of these may be seen in Fig. 14. After the sides and ends were assembled and bolted in place the joints were poured full of lead. The upper and lower edges of the flasks then were planed and finished.

All flasks are rammed upon special bed plates machined to a level surface and set upon a firm foundation in the floor. The flasks are matched by two 1-inch pins on opposite ends which are drilled to template on center lines.

To avoid a multiplicity of bars in the different cheek sections, two collapsible arbors are used in each cheek flask. These arbors bolted to the sides of the flask give the necessary support to the sand and add to the rigidity of the mold section as a unit. The arbors are box or grilled section, heavily constructed and are held to the sides of the flasks by two bolts through each side of the flask, at each corner. This provides eight bolts supporting each section of the arbor. These are easily loosened and the flasks may be slipped from the sand and the castings in shaking-out. The bolts holding the arbors in place may be noted in Fig. 19.

For convenience in handling, each cylinder is molded in four units, consisting of the drag and barrel core as one unit, the lower cheek, the upper cheek and the cope. The cope in each case carries the mold for the upper portion or head of the cylinder. The parting lines may be noted from Figs. 6, 10 and 13. Three full patterns

served through until the present time. Great strength, and accuracy in the rig used and a perfect co-ordination between the gangs handling the work have been responsible for the speed made.

The heavy castings for triple expansion marine engines include the high, intermediate and low-pressure cylinders; six main columns which support the cylinders and serve as cross-head guides; heavy cylinder heads and pistons and the bases. Up to the present time the Hamilton company has successfully made over 940 cylinder castings, bases for the number of engines these cylinders would supply, one pair of columns for each of that same number of engines, and a great variety of light work required for the job. Floor space has been the sole limiting factor which the foundry has been unable to overcome. This lack of room made it necessary to send out rigs for making the other four columns for each engine to subsidiary foundries, and also to let out some of the lighter work. These all are made according to the system pursued in the Hamilton foundry.

The cylinders formerly were considered the limiting element on marine engine building. This limit practically was removed at once. Up to the latter part of February this year, with 940 cylinders cast, only two

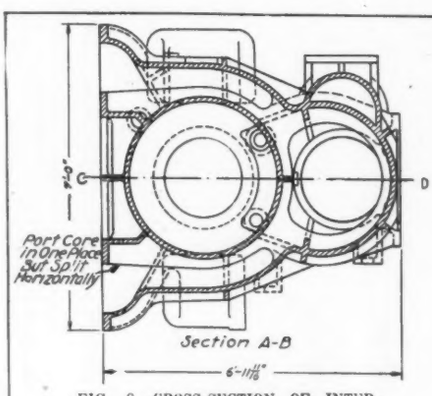


FIG. 8—CROSS-SECTION OF INTERMEDIATE CYLINDER

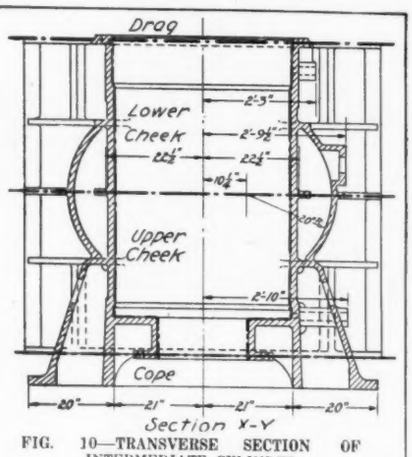


FIG. 10—TRANSVERSE SECTION OF INTERMEDIATE CYLINDER

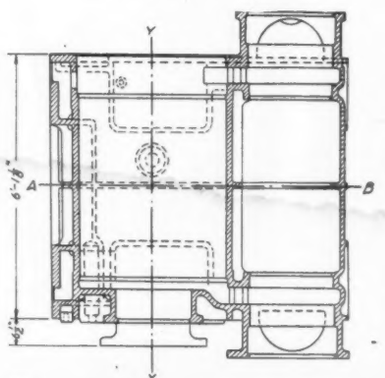


FIG. 9—SECTIONAL VIEW OF INTERMEDIATE CYLINDER

are provided for each of the bed plates upon the floor for cylinder work. One gang is employed in ramming drags, two others on cheeks, one gang on copes and still another on assembling. This division of operations develops teamwork among the working units and has secured greater efficiency and skill on the different jobs.

The drag and barrel core are made together. The drag flask is placed on one of the bed plates on the foundry floor and rammed full of sand. A spindle is set at a point which answers for a center. With this spindle as a fixed point, loose pieces are bedded-in to form the portion of the bottom of the cylinder which is carried in the drag. The barrel core then is rammed in a cylindrical, hollow box. The three barrel cores are shown nearly ready for the ovens in Fig. 15. This photograph was taken after about six hours' work on the three drags.

A mixture of one-half new and one-half old sand is used for the drags and barrel cores. No compound is employed.

Each of the drags is baked overnight in a gas-fired core oven. The following morning the valve chamber core for the low pressure cylinder, which has been baked previously, is set in place, all bolt holes, etc., are filled and the drag with the new core

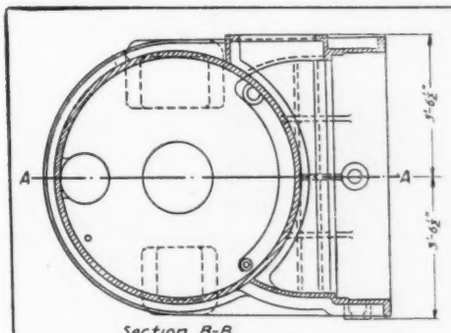


FIG. 11—CROSS-SECTION OF LOW-PRESSURE CYLINDER

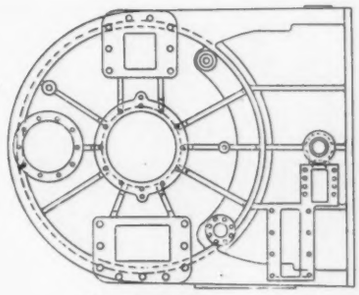


FIG. 12—HEAD OF LOW-PRESSURE CYLINDER

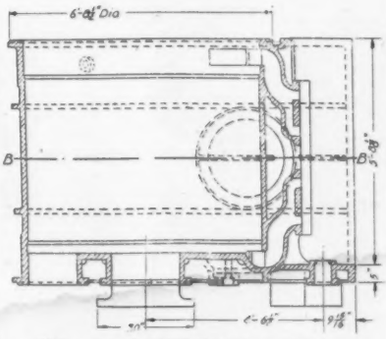


FIG. 13—LONGITUDINAL SECTION LOW-PRESSURE

added is returned to the oven to be baked again. The drag for the high and intermediate cylinder is ready for assembly after only one night's baking. In this way two complete sets of flasks for each cylinder are required with an extra drag flask for each, except only the low pressure cylinders, which requires two extra drag flasks.

The patterns for the cylinders are divided horizontally on the parting lines and are in sections. The cheeks and copes are rammed-up on bed plates that will be described later, and all are rolled over. After molding, the inside of each of these latter molds is sprayed with blacking and wiped smooth. The molds then are dried over night.

An ingenious method has been developed to overcome the lack of floor space and to dry the molds thoroughly and quickly. The area between the trackways leading into the drying ovens in which the drags and inner cores are placed, ordinarily would be considered waste space. This foundry utilizes even this portion of the floor. The core oven cars are flat heavy platforms which are moved upon iron balls that roll in two heavy V-shaped trackways into each oven. A trench was constructed in the space between adjacent pairs of ovens. In this trench a long flame gas burner was placed and the top of the trench was covered over with perforated plates. In drying the molds overnight, the lower cheek is placed over the improvised drying furnace between two core ovens. The flask edges rest upon the inner rails of two neighboring trackways previously referred to. The second cheek then is placed upon the first, but with the edges of the two flasks wedged apart to allow the free passage of air. The cope in the same manner is placed on the two cheeks. This forms a drying oven of the molds themselves. The gas flame under the perforated plate beneath, dries all the molds together. This method proves most effective, and each day's mold sections are ready for assembly and pouring on the following day. The detailed procedure followed for the three cylinders are similar up to this point in the work.

The high pressure cylinder, drawings of which are shown in Figs. 5, 6 and 7, is 29 inches in diameter and carries with it the chamber of a piston valve housing. The core for this valve chamber is complicated. According to his plan of operation, the superintendent assembles as many cores as possible upon one arbor, to save time in setting the cores in place. The complete core is shown in Fig. 16. The first cores made were

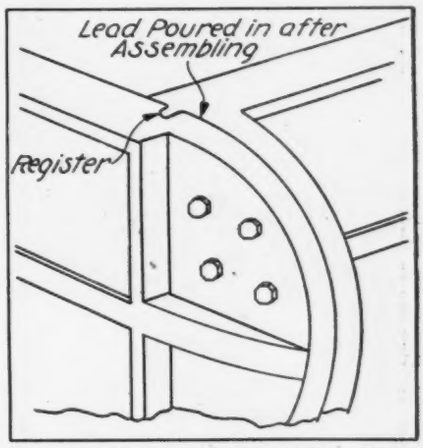


FIG. 14—DETAIL OF FLASK CORNER SHOWING REGISTER USED TO SECURE RIGIDITY

assembled upon a flat plate in the usual manner. All hook holes and bolt holes then were filled and the entire core baked. It was necessary to set the completed core upon end in order to place it with the barrel core on the drag. To accomplish this the plate had to be tilted with the lower edge resting on a bed of sand, until the upper end of the core was raised sufficiently to engage the bolt holes with the hooks from the crane auxiliary. Then, by careful handling, the plate was elevated vertically and the core was swung free with its base resting on the sand bed, without knocking off the corners nor damaging the core.

This method, requiring almost an hour to complete, proved too slow for the work at hand, so the rig shown in Figs. 16 and 17 was devised. The integral cores here are assembled according to the method described, but in a horizontal position on the special bracket plate. After baking, the rig is picked up and removed to the point near the high pressure drag where the core is to be raised erect. Two wooden braces or straps are thrown across the core, one at each end. The one is secured to the base plate by long bolts, and the other is wedged under the arms of the bracket. Burlap protects the core at the points where the straps touch. Special hook holes are supplied on the end of the plate which is to be elevated, and engaging these the crane sets the rig on end,

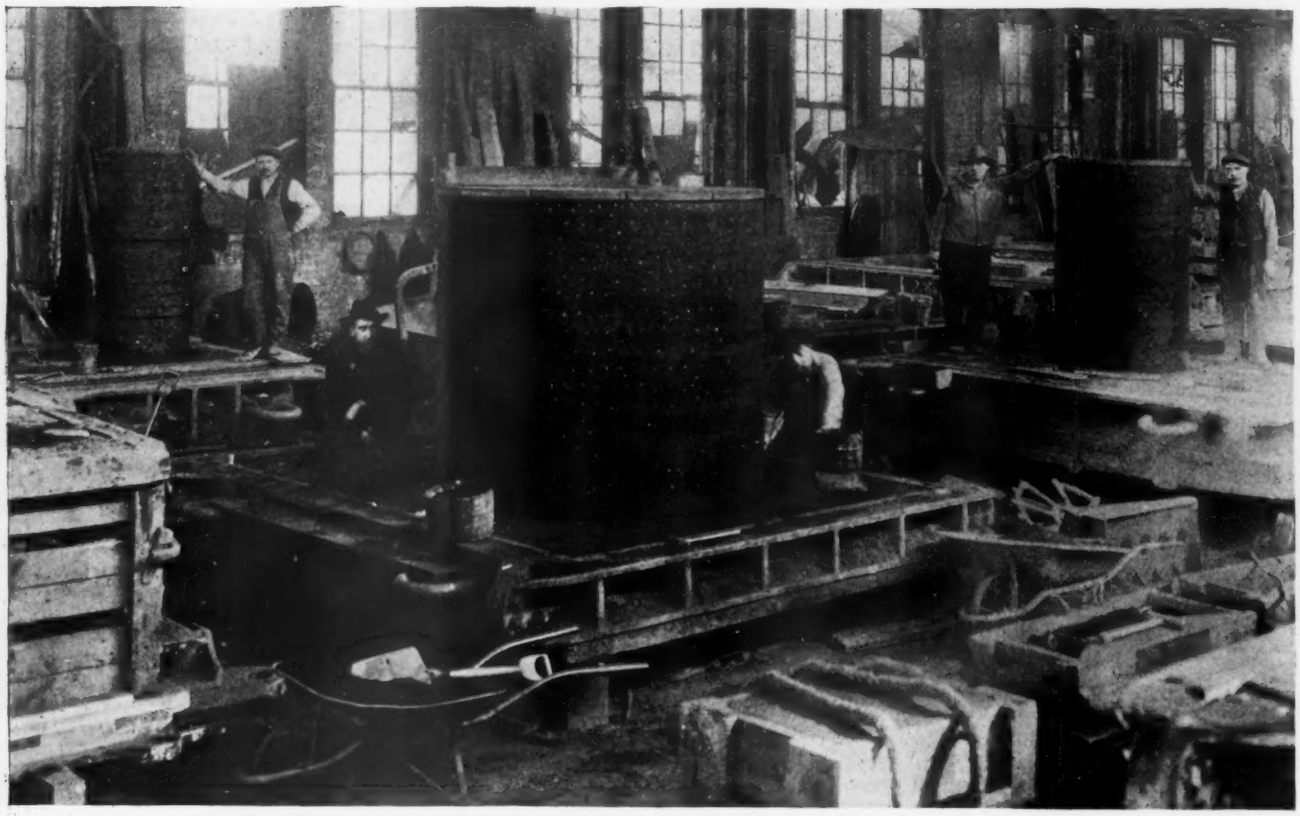


FIG. 15—THREE DRAGS AND BARREL CORES FOR THE THREE CYLINDERS NEARING COMPLETION EARLY IN THE AFTERNOON—THESE ALL ARE BAKED OVERNIGHT

as shown in Fig. 17. The straps then are removed and the core is lifted and swung into place on the drag by hooks engaging eye bolts in the upper end. Setting the valve core with this rig requires only five to ten minutes. The time consumed in the entire operation, assembling the drag with its barrel core, the cheeks, valve core and closing the mold for the high pressure cylinder, is performed in less than six hours.

The intermediate cylinder is undoubtedly the most difficult to mold. The piston type intake valve is located on one side of the main cylinder. The exhaust discharges through ports at opposite sides of the cylinder. The cores for these ports, which may be seen, Figs, 9 and 10, are made in two halves, split horizontally. The lower half is placed on the drag after the first cheek is in place. The top section of the port core is placed as shown in Fig. 18. The top cheek is then put on. Cores are never pasted together in this shop. In this case the two halves of the exhaust port core are set in the mold and vented separately. The vent for the lower section is shown set in Fig. 19. The smaller side cores are set in place before the cheek is removed to its place on the mold. Chaplets are used only to assure the proper spacing of cores.

The intermediate cylinder molds, though considered the most difficult

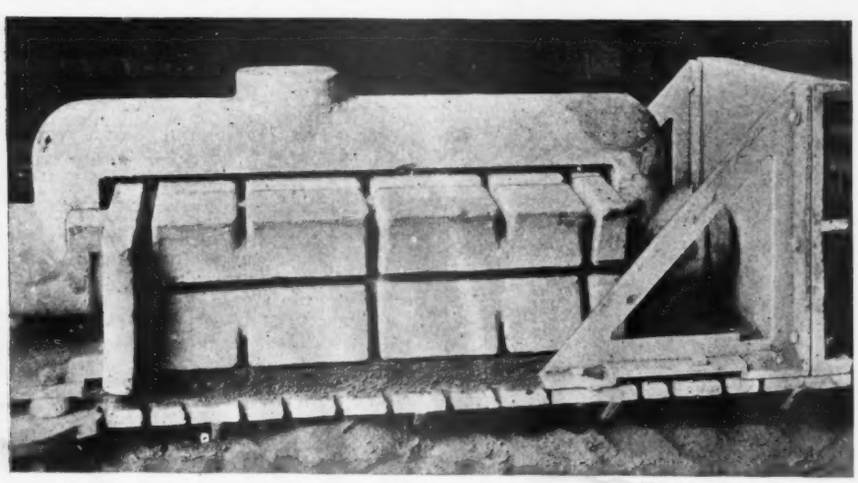


FIG. 16—CORE ASSEMBLY FOR VALVE CHAMBER OF HIGH-PRESSURE CYLINDER AS IT IS BUILT-UP ON THE SPECIAL BRACKET PLATE AND BAKED

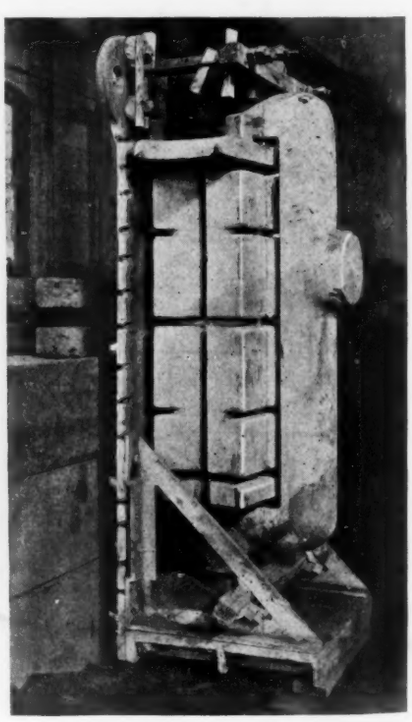


FIG. 17—HIGH-PRESSURE VALVE CORE SET ERECT AND READY FOR THE REMOVAL OF THE STRAPS PREPARATORY TO PLACING IT IN THE DRAG

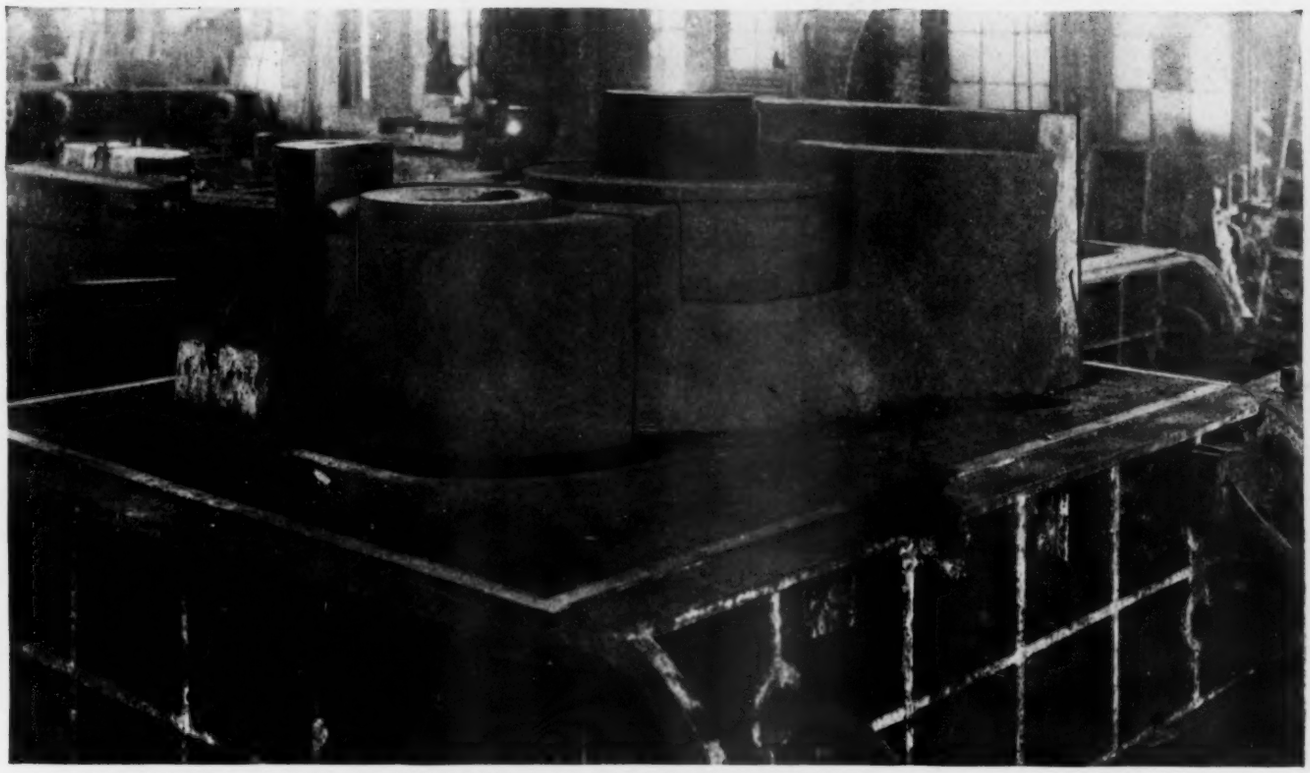


FIG. 18—DRAG AND LOWER CHEEK FOR THE INTERMEDIATE CYLINDER WITH THE EXHAUST-PORT CORES IN PLACE—NOTE HOW THESE CORES ARE DIVIDED IN HALF HORIZONTALLY FOR PLACING IN THE MOLD

are assembled before 2:30 each afternoon. The molders commence work at 6 a. m. and the rapidity with which they work may be judged from Fig. 19. Here the center cores are in place and the first cheek set. The second cheek is lowered in place at 9 a. m.

It will be appreciated that accuracy is paramount when the several sections of a core are combined into one large unit as is the practice in this cylinder molding work. Care is observed in every operation. Furthermore, a special system for handling the core boxes has been devised to prevent distortion. All of the heavier cores are made in boxes similar to that shown in Fig. 20. The box is placed upon a well designed plate that is planed to a true surface. After the core is rammed, the surface is struck-off as true as possible and a second plate which is to serve as a drying plate, is put in position. The two plates then are bolted together at the four corners, as shown. Two clevis and pin fastenings then are bolted to the edge of the lower plate. The crane chains engage these and lift the bottom plate, rolling-over the core box and the entire rig upon the drying plate. In this manner the box is not engaged by the crane hooks and no chance develops for distortion in the box or the core within. Loosening the bolts permits the top plate to be removed, and the core box sections are unfastened and drop away. The resultant accuracy in cores

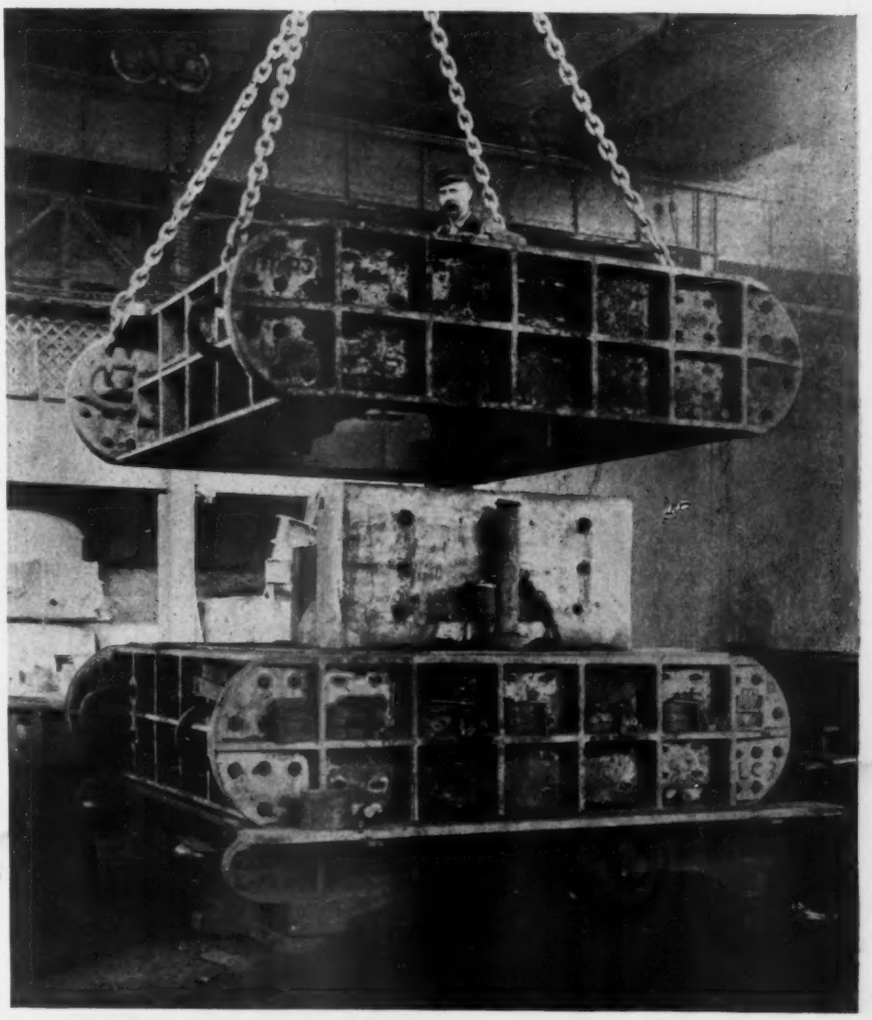


FIG. 19—LOWERING THE SECOND CHEEK INTO PLACE ON THE MOLD FOR THE INTERMEDIATE CYLINDER—NOTE THE LOWER CORE VENT AND THE ARBOR BOLTS IN THE CHEEKS

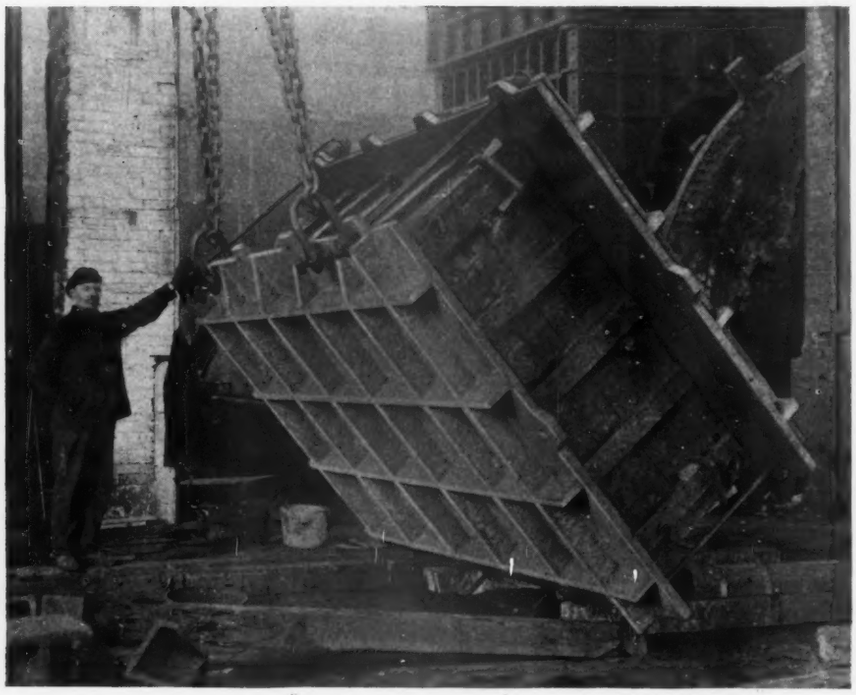


FIG. 20—A SPECIAL METHOD IS FOLLOWED IN ROLLING-OVER LARGE CORES

is not the only factor of advantage of this method of handling as the core box is subjected to less wear than otherwise would be the case. The core box shown in Fig. 20 has been in steady use for over 18 months.

Used, ground core sand, mixed with a small amount of pitch and new sand is employed for all of the larger cores in the marine engine work. Arbors are plentifully used throughout. The arbors are made in the foundry, a bed of molds being in readiness in odd corners at all times to pour the surplus metal from any casting. The cores are baked in natural gas, under-fired ovens, provided with a single burner

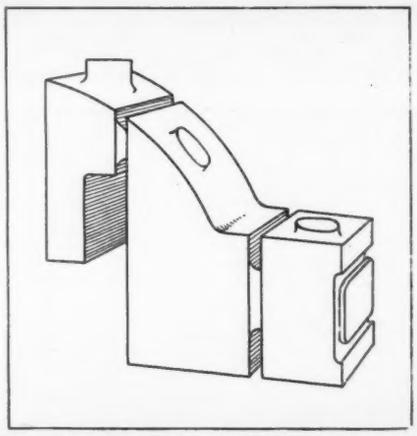


FIG. 21 — THREE CENTER CORES JOINED TOGETHER FOR THE BASE SECTION

each. The heat travels from back to front in an under flue and then back to the rear in the oven chamber. One damper at the top and one at the bottom in the back of the oven control the currents. The top damper is left open for about three hours after the cores are placed, to allow the steam to escape freely. This then is closed and the bottom damper is opened to give freer circulation. Pyrometers are used to record the heat, and an average of 600 degrees Fahr. is maintained. Six of these ovens are in service.

Low Pressure Cylinder is Simple

The low pressure cylinder involves only a slight variation in molding. The drag, with the barrel core, is shown in Fig. 2. This core is 72 inches in diameter. The flange around the top is a chill which is constructed in sections. This is to provide against segregation between the cylinder walls and the head.

The main valve chamber core is shown in Fig. 3. The steam inlet from the intermediate cylinder is controlled by a slide valve which operates in a chamber between the two cylinders. Steam is admitted through slots in the sides of the cylinder which are cored out. The valve-chamber core is molded in the position shown. An arbor set in the base, to which rods are bolted, lends rigidity to the core. After baking overnight as has been mentioned, the entire core is picked up by the bars shown in Fig. 3, and set upon the drag in the position indicated in Fig. 4. The lifting bars then are slipped out and the holes in the core are filled.

The assembled core then is replaced in the oven and again baked over-

FIG. 22—THE COLUMNS ARE MOLDED GUIDE-UP AS PLACED IN THIS ILLUSTRATION—THE PARTING LINE FOLLOWS THE UPPER EDGE

night. The drags, therefore, must be made two days in advance of the complete assembly of the mold. The work upon all cores is so carefully co-ordinated that at no time does a delay arise due to waiting for a necessary unit. The interval elapsing between the time when Figs. 2 and 4 were photographed was only about 15 minutes.

Pouring the Cylinders

When the flasks are assembled into the complete mold, clamps are wedged at frequent intervals as may be noted in Fig. 1. These are designed to take all of the lifting stress in the mold when the metal is poured. The weights shown on the top of the mold are intended only for platforms on which the men who handle the ladles in pouring may stand. The runner box is shown in place on the mold. This runner feeds a number of sprues which lead directly to the wall of the cylinder. The metal drops to the bottom along this wall and feeds up into the other portions of the casting. Seven large risers are provided in the tops of the cylinders. Vents are used plentifully, and as has been indicated, separate vents for each core section are carried to the outside of the mold. Those which come to the top of the mold lead into pipe extensions which carry the gas over the heads of the workmen in charge of pouring. A 25 per cent semisteel mixture is used on the large marine castings. About 40 tons of this metal is poured daily.

The cylinders usually are poured between 2:30 and 3:30 p. m. They are allowed to remain in place until the night shift comes on at which time they are removed to the shakeout floor. Here the clamps are knocked off, the bolts holding the cheek arbors are loosened and the castings are shaken-out. The flasks are sufficiently cool to be used again the next morning. The sand is left around the castings until the following day when the cores are broken out, and the sand jarred loose. Castings then are removed to the cleaning floor in a wing adjoining the foundry floor. Pneumatic cleaning tools serve to remove the sand and surface blemishes. The castings finally are immersed in a sulphuric acid pickling solution for 24 hours before removal to the machine shop for inspection.

Each cylinder before it is accepted is sealed and subjected to hydrostatic test. The hydraulic pressure which must be exceeded without indication of leaking is 300 pounds for the high pressure, 150 pounds for the intermediate and 50 pounds for the low pressure cylinder. Triple inspection is made by representatives from the Emergency Fleet corporation, Lloyd's and the American bureau of shipping.

Molding Other Engine Parts

Molding the bases and columns for marine engines also has been effected with radical changes from accepted practice. The bases for the 850 and 1400-horsepower units were cast in one piece. That for the 2800-horsepower engine, however, is made in three sections, each similar to the one shown in Fig. 23.

In this job, two heavy flasks similar to those used for the cylinders are employed for each piece. These also are machined to a close joint and are matched by two holes drilled on a center line to template. The large square core forming the central part of the bed-section or crankshaft pit is made on a plate to facilitate handling, finishing and setting. This core is shown in Fig. 21. In accordance with the practice in this shop, cores that would customarily be regarded as three separate units are combined into a single core on a heavy arbor. Joining the cores obviates a number of separate core boxes and considerable labor in setting. Furthermore, it eliminates chaplets used to secure the proper spacing between the parts of the multiple core. By simplifying this coremaking the molding and casting of three complete base sections per day is made possible without difficulty.

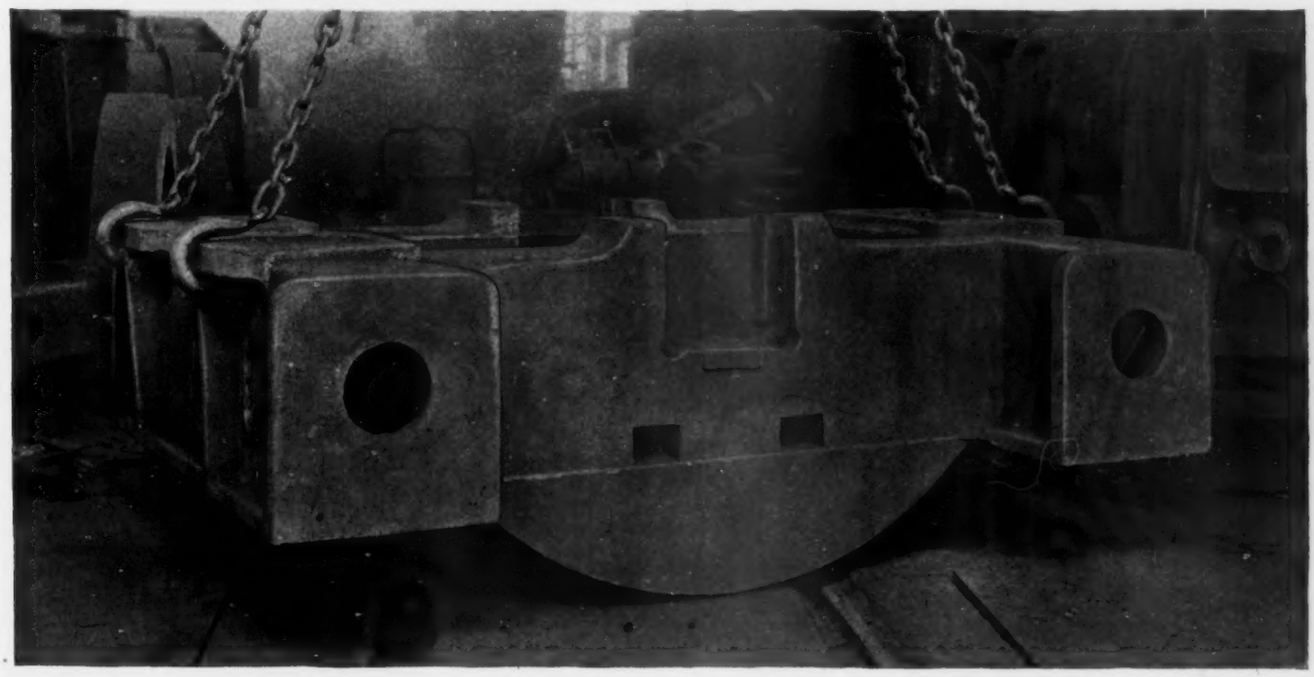


FIG. 23—THE SECTIONS FOR THE BASE OF THE 2800-HORSEPOWER ENGINE ARE CAST IN TWO FLASKS IN A POSITION INVERTED FROM THAT SHOWN —THE ARRANGEMENT OF THE CRANK-PIT CORES IS SHOWN IN FIG. 21

The greater portion of the base section is carried in the drag. It is molded bottom up with the curved portion in the cope. The parting line is plainly evident in Fig. 23.

Precedent dictated that the column shown in Fig. 22 should be molded with the guide down, but in this foundry the casting is made in the mold in the position in which it is shown in the illustration. Each engine requires six of these columns to support the cylinders. The three front columns which are placed opposite the three back columns are plain box section. The back column shown, is forked at the base, a detail which is not apparent in the illustration. Furthermore, it has the bracket which the front columns lack. Two other foundries are engaged in making columns for

the Hooven, Owens, Rentschler Co. These employ rigs furnished by the Hamilton foundry and follow the same molding procedure.

The mold for the columns is made in two flasks. The parting line is visible in Fig. 22, along the line *DD*. Sound metal is essential in all parts of these castings, but more particularly in that part of the column which forms the crosshead guide. A clean face for the guide is imperative. It was believed that only by molding the column with the guide down would it be possible to attain this condition. The superintendent of this foundry desired to avoid the use of bars in the cope flask, which would have to be changed for the front or back column. He was of the opinion that the cope would be as clean as the drag if the mold were properly gated. This theory is supported by the results attained. The mold is poured from the bottom in order that any slight dirt in the mold may be caught under the core and prevented from reaching the upper edges of the casting. Over 60 sets of these columns had been machined in the company's shops without developing any imperfection.

Fracturing Heads and Risers From Steel Castings

By G W Merrefield

SHRINKAGE forces, as shown in so-called *hot-breaks* are familiar in all classes of steel castings. The deliberate application of this force to serve the legitimate purposes of the foundryman, however, is rare. In the plant in which the writer is employed the force developed in the shrinkage of steel castings is used to break off the shrinkage heads or risers. This is accomplished by using a hard core, ⅜-inch thick, around the neck of the riser. This core has a firm bearing and the shrink-head at the line of junction with the body of the casting, so that when the casting and head cool, the stress which develops is met by the unyielding core. The result is a slight fracture at the neck of the riser. This fracture produces a plane of weakness, so that a slight tap from a hammer serves to remove the riser from the casting.

The fracture core idea was the result, as are most innovations, of trouble experienced in following the usual practice. In the casting of disk truck wheels, risers were placed at the edge of a flange on the outer hub. This flange was devised to accommodate a hub cap to be later bolted in place. It was found that in knocking off the risers, a piece of the flange usually broke away in the manner shown in Fig. 1. The hard oil sand core shown in Fig. 2 was developed and was placed in the

FIG. 1 — STEEL WHEEL HUB WITH FLANGE BROKEN IN REMOVING SHRINK-HEAD WITHOUT FRACTURE CORE

FIG. 2—CORE USED TO BREAK RISERS FROM THE FLANGES OF WHEEL CASTINGS BY MAKING PLANE OF WEAKNESS

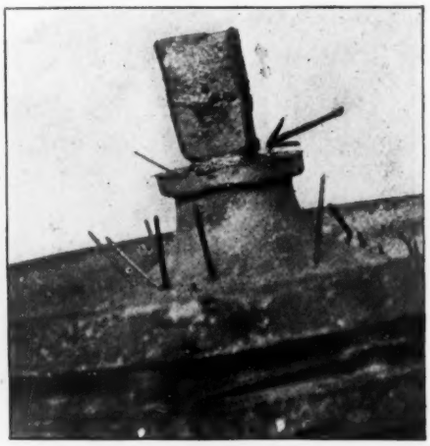


FIG. 3—WHEEL CASTING WITH LINE OF CLEAVAGE BETWEEN RISER AND FLANGE INDICATED BY THE ARROW

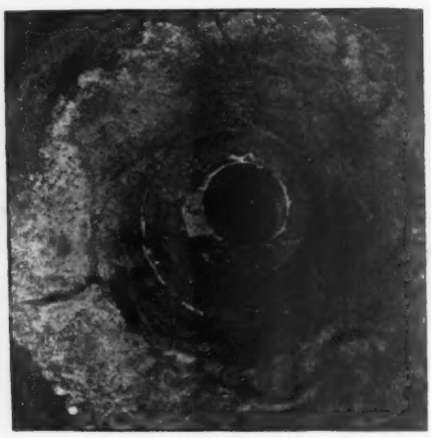


FIG. 4 — THE USE OF THE FRACTURE CORE RESULTED IN A CLEAN BREAK WITHOUT INJURY TO THE FLANGE

FIG. 5—HARD, OIL SAND CORE USED TO FRACTURE SHRINK-HEADS FROM THE HUB CASTINGS FOR WOOD WHEELS

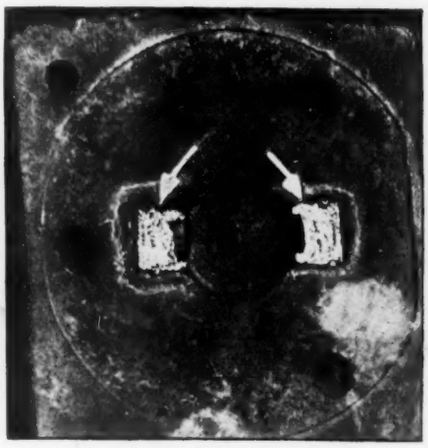


FIG. 6—COPE HALF OF HUB MOLD, SHOWING THE TWO FRACTURE CORES IN PLACE TO FORM THE LINE OF BREAKAGE

cope half of the mold sufficiently obstructing the riser opening to form a distinct cleft between the riser and the casting. The result was a line of cleavage sharply defined, as may be noted in Fig. 3. The shrink-head broke away from the flange leaving a clean surface as may be seen in Fig. 4.

The idea subsequently was applied to the production of hub castings for wood wheels. The core used in this case is shown in Fig. 5. Before using the fracture core, the head usually removed a piece of the hub. With the use of the shrinkage core, a clean break was obtained and no welding was required. The core shown is about ⅜-inch thick, and was placed so that the riser was allowed about one inch of bearing on the core. The cope cores are shown in Fig. 6.

An additional advantage of the shrinkage core is the fact that the fracture always is clean and does not tend to follow varying lines into the main structure of the casting. The character of the break obtained may be noted from Fig. 7. In this case *A* and *C* were broken off by shrinkage cores while *B* was removed in the customary manner.

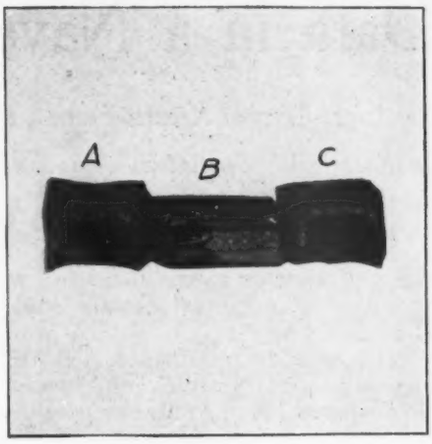


FIG. 7—FRACTURED SECTIONS OF RISERS—*A* AND *C* RESULTED FROM THE USE OF SHRINKAGE CORES, *B* FROM FORCED BREAKAGE

Results of Heat-Treating Bronze Castings

(*Concluded from page* 194)

in Fig. 18 had the following properties:

Yield point, lbs. per sq. in.	22,700
Tensile strength, lbs. per sq. in.	55,200
Elongation, per cent	9.0
Reduction of area, per cent	11.2
Brinell hardness	109

It is evident from the foregoing that 10 per cent aluminum bronze castings should not be allowed to cool slowly in their molds, but must be shaken-out of the sand as soon as possible and cooled quickly in the air if good tensile properties are desired. Casting in a chill mold is still better to prevent any self-annealing. It follows also that very large sand-castings in which strength and ductility are important should not be made of an alloy containing this beta constituent which is so subject to deterioration on slow cooling. It has been found, however, that castings containing the unstable beta will not begin to change into the brittle form even after several months exposure to steam temperatures, so that the use of this alloy in steam fittings is not dangerous.

For use in bearings, or in gears, pinions, etc., the presence of the hard delta constituent in the stable eutectoid is probably an advantage over the unstable and less hard beta. Thus, for such purposes, a certain amount of annealing, either in the sand or after a slight forging to reduce the grain-size, may confer desirable properties in regard to wear or friction, if the reduction in strength and ductility may be disregarded.

Aluminum bronze of such composition as to contain eutectoid or beta, therefore, is seen to be susceptible to change by heat-treatment in a very interesting way, and a thorough understanding of the effects of different treatments are almost essential for the successful manufacture of this alloy for particular purposes.

Removes Office and Laboratory

Herman A. Holz, metallurgical engineer and manufacturer of metallurgical and magnetic testing apparatus, has removed his office and laboratories to the Pullman building, 17 Madison avenue, New York. The laboratories will be equipped for experimental heat-treating, hardness and impact testing, micro and microphotographic investigations of metals, apparatus for magnetic measurements and for investigating the mechanical properties of steel production by determination of correlated magnetic characteristics.

Westinghouse, Church, Kerr & Co., New York, engineers and constructors, have established an office in the Western Indemnity building, Dallas, Tex., in charge of A. W. Nichols.

Foundrymen Will Meet in Philadelphia

THE twenty-fourth annual convention and the fourteenth exhibition of the American Foundrymen's association will be held at Philadelphia during the week of Sept. 29. This will be the third visit of this organization to Philadelphia where it was formed in June, 1896, and another meeting was held in that city in 1907. The convention and exhibition will be made international in scope and invitations will be extended to foundrymen and industrial engineers in England, France, Belgium, Italy and other European countries. The rehabilitation of the iron and steel industries of France and Belgium undoubtedly will involve the installation of a large amount of American equipment and this exhibition will afford manufacturers in these countries an opportunity to inspect at one time the latest and most improved devices for foundries and machine shops.

The Exhibition

The exhibition will be held in the Philadelphia Commercial Museum, located along the Schuylkill river in that part of the city known as West Philadelphia, at Thirty-fifth, below Spruce street. The building has a private Pennsylvania railroad siding for unloading carload shipments and is only five blocks from the West Philadelphia yards of the Pennsylvania railroad. Exhibition hall of the Commercial Museum is one of the largest buildings of this kind in the country. It has 88,000 square feet of exhibition space on one floor, is well lighted and the ceilings are 40 feet in height in the clear. It has a cement floor capable of carrying almost any load and openings may be cut through for special foundations or operating pits. This feature will insure a large amount of operating machinery which will prove of added interest.

Philadelphia is one of the leading foundry centers of the United States and contiguous to it is the great steel casting producing district of which Chester is the center. From the standpoint of interest, both historical and industrial, Philadelphia has much to offer visitors. The great Hog island shipyard, with its 50 ways is an attraction worthy of a trip to this city and, in addition, large new foundries have been added to the League island navy yard and at Essington, near Philadelphia, is the large foundry erected during the war by the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Compiling Cost Data in a Naval Steel Foundry

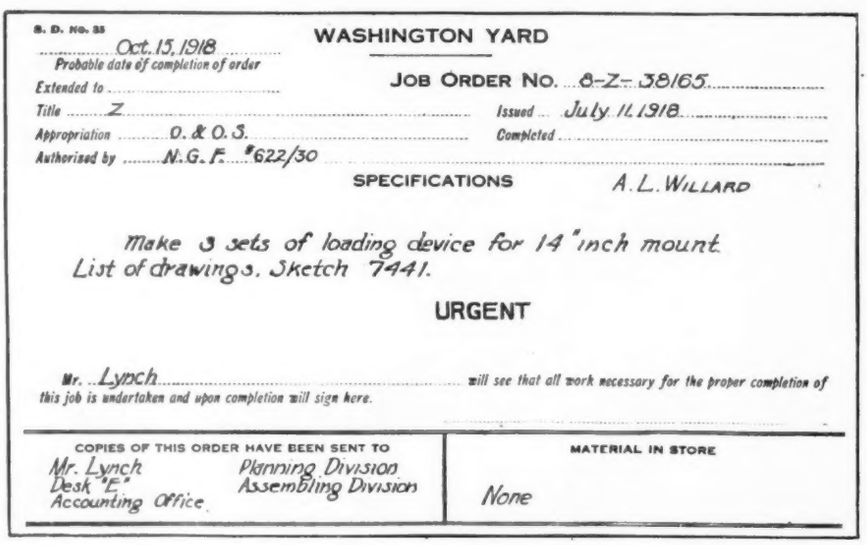
Complete System of Cross-Checked Reports Form a Basis for Production and Cost Analyses—All Operations Are Followed Accurately

By Lieut Walter S Doxsey

ALWAYS closely allied with engineering progress, improved and accurate cost accounting systems are rapidly becoming as characteristic of modern foundry practice as the many labor-saving and cost-reducing devices which have been so widely introduced into progressive foundries during the last decade. The fundamental necessity of knowing in a general way the cost per pound of castings produced has been greatly accentuated by the advent of large scale production of standardized parts and by keener competition among foundries. These factors have served to emphasize the importance of reliable cost data and have brought the foundryman to look upon the accountant's tell-tale figures as a blessing rather than as a necessary evil. War conditions capped the climax for under stress of driven production it was not only highly desirable, but imperative, for the manufacturer to know definitely his manufacturing costs per unit of product. Contracts for the multifarious accessories of warfare greatly increased the clerical work in foundries by requiring comprehensive inspection reports at various stages of production as well as demanding accurate systems of cost accounting. While the maintenance of such records imposed considerable additional duties and responsibilities upon the foundry superintendent, the value of these data are indisputable and indispensable. Furthermore, after a suitable system has been inaugurated, the recording of inspection and cost data becomes more or less mechanical and the clerical work in a large foundry can be handled by a surprisingly small force.

The records maintained by the foundry at the naval gun factory, Washington, D. C., offer an example of the comparative simplicity of securing exhaustive data on the physical characteristics of the metal melted, the progress of work on the floor, and for computing the cost per pound of finished castings. In contrast to foundries devoted to the highly specialized production of a few types of castings on large contracts, the naval gun factory foundry turns out a widely diversified assortment of castings in gray iron, steel and brass, varying in weight from a few ounces to several tons and from the most simple to those of greatest intricacy. Although this condition tends to complicate the maintenance of records, specific data on the wide range of products are secured expeditiously with a minimum of clerical work. While the system in use at the naval gun factory foundry is applied to steel, brass and iron foundry practice, the following description is devoted only to the steel foundry and shows how data are gathered in the foundry for the foundry files, the inspector and the accounting office.

Records of inspection, estimating and cost accounting pertainng to the manufacture of ordnance material at the naval gun factory are supervised by three separate, yet interlocking, divisions: The planning division, the inspector of ordnance, and the accounting office. The functions of these divisions are indicated perfunctorily by their respective names. Orders for material, which have their inception in the superintendent's office are sent to the planning division where subsidiary orders are issued to the shop that will execute the various operations of production. Thus, if the superintendent issues an order for a new gun carriage, the planning division will send the subsidiary orders to the pattern shop, the foundry, and the machine shop. The accounting office is responsible for accurate data on the cost of the work done in the shops on each individual order and the inspector sees that the quality of material and machine work is in accordance with the navy department specifications under which all ordnance is manufactured at the naval gun factory.



B. D. No. 35

WASHINGTON YARD

Oct. 15, 1918
Probable date of completion of order

JOB ORDER NO. 8-Z-38165

Extended to

Title Z

Issued July 11, 1918

Appropriation O. & O. S.

Completed

Authorized by N.G.F. #622/30

SPECIFICATIONS A. L. WILLARD

Make 3 sets of loading device for 14" inch mount.
List of drawings. Sketch 7441.

URGENT

Mr. Lynch will see that all work necessary for the proper completion of this job is undertaken and upon completion will sign here.

COPIES OF THIS ORDER HAVE BEEN SENT TO	MATERIAL IN STORE
Mr. Lynch Desk "E" Accounting office Planning Division Assembling Division	None

FIG. 1—JOB ORDER FORM FOR PLANNING DIVISION

Orders originating in the superintendent's office are sent to the planning division on a job order form similar to one shown in Fig. 1. On this order is included all the information necessary to identify the article to be made and to enable the planning division to route the work properly through the shops for manufacture.

When the planning division receives a job order requiring castings, a material list, as shown in Fig. 2, is prepared. This list shows the various castings required by the order. Under the head "pattern" on this form is placed a character which shows the status of the pattern. The estimator, who is a representative of the planning division, confers with the fore-

Abstracted from a paper presented at the annual meeting of the American Foundrymen's association. The author, Lieut. Walter S. Doxsey, was stationed at the Washington navy yard.

man of the foundry and from the blue prints of the casting figures the cost of the metal per pound of the finished piece. This estimate is divided into items of material and labor and entered in the proper columns of the material list. While the estimated cost is not held as an absolute criterion of the value of the finished casting, the final exact cost as computed from the foundry data sheets by the accounting office must be within 10 per cent of the estimated cost or an investigation is made to determine the discrepancy.

After estimates have been made and dates of delivery determined with due consideration for the immediate need for the castings and with proper cognizance of the prevailing conditions in the foundry, subsidary or foundry shop orders are written by the planning division for each casting. These subsidiary orders contain all the information and authority necessary for a shop to proceed with the work required. The foundry shop order, as may be seen by referring to Fig. 3, is similar to the superintendent's order, Fig. 1, but is more comprehensive and embodies the additional information furnished by the planning division. The supply officer's copy shown in Fig. 3, is the original; the other five, one of which is illustrated in Fig. 4, are carbon copies and are distributed as follows: Foundry file copy, molder's copy, coremaker's copy, accounting office copy, and machine shop copy.

The original, or supply officers' copy, as shown in Fig. 3, is filled for illustrative purposes similar to an actual order. The legends preceding the blank spaces and at the heads of the columns are largely self-explanatory. The "job order" number is the same as the one entered on the superintendent's order and serves to identify the subsidiary with the original order. After the word "shop" is filled in the name of the shop to which the castings are to be delivered—in this case, the machine shop. The "Stub No." is a serial number individual to foundry orders. Since,

MATERIAL LIST. CASTINGS.

N. G. F. 386.
Job Order No. B-Z-38165. Estimate No. 5-14-178
Prepared by R. C. H.
Shop E. Date July 15, 1918. For Loading Device for 14-inch Mount.

Drawing No.	Cor.	Piece No.	No. Reqd	Name of castings and material or quantity and description of material	Specifications	Symbol	Rough Wt.	Price per lb.	Req'n No. Stub.	Req'n No. Scrap.	Pattern	Labor.	Material.
57832	A	1	12	Tray wheels Steel. Grade B	49 S1d	Dr.	10"	.09	13537	None	C	9.00	10.80
57832	A	2	9	Track Roller Steel, Grade B	49 S1d	Dr.	15"	.09	13538	None	C	6.57	12.15
57834	A	1	6	Track Support Front & Rear Steel Grade B	49 S1d	Dr.	124"	.09	13543	None	C	17.52	66.96
57834	A	6	3	Track Support-Intermediate Steel Grade B	49 S1d	Dr.	124"	.09	13544	None	C	8.76	33.48

FIG. 2—MATERIAL LIST FOR CASTING ORDER

Chemical and Physical Requirements for Navy Steel Castings

(Taken from Navy Department Specifications 498Id.)

Grade	Chemical Composition Not over P.	S	Physical requirements: Minimum tensile strength Pounds per square inch.	Minimum yield point Pounds per square inch	Minimum elongation Per cent in 2 in	Minimum reduction of area Per cent.	Bending test; cold bend not less than
F	0.05	0.05	85,000	53,000	22	35	120° about an inner diameter of 1 in.
A	.05	.05	80,000	45 per cent of	17	20	90° about an inner diameter of 1 in.
D	.05	.05	70,000	tensile strength	22	30	120° about an inner diameter of 1 in.
B	.06	.05	60,000	obtained.	22	30	Do.
C	.06	.07	.....	.....	..	..	

Note.—Class F castings may contain nickel or other alloying metals.

SUPPLY OFFICER'S COPY

FOUNDRY SHOP ORDER

Ord. Rec'd 7-17-18
Pat. Req. 7-17-18
Pat. Rec'd 7-19-18
Core Started No. Cores
Mold Started 7-23-18
Molder Roach
Pat. Ret'd 8-7-18

Job Order B-Z-38165 Shop Erecting
Stub No. ZE-13543 Date 7-16-18 No. of pieces 6
Specification 49 S1d Grade B Estimated weight per piece 120
Date of first delivery 9-1-18 (To be ordered by shop ordering the castings
Date of last delivery 8-15-18 in accordance with promised date of completion
Pattern Status In the Loft V New Pattern In the Foundry
(Date of Completion)

Description	Number Molded	Heat No.	Date	Weight	Number Shipped	Date Rec.	Receipt No.	Signed By
Track Support (Front & Rear) Loading Device etc	1	E 185	7-28	248	2	8-9	H 3768	Special
	2	E 188	7-30	124	1	8-10	H 3779	Special
	1	E 194	7-31					
	2	E 204	8-5	372	3	8-15	H 3850	Special

Rejections No.	Date

Blue print No. 57834-A Piece No. 1 M. M.

FIG. 3—FOUNDRY SHOP ORDER—SUPPLY OFFICER'S COPY

MOLDER'S COPY

FOUNDRY SHOP ORDER

Job Order B-Z-38165 Shop Erecting
Stub No. ZE-13543 Date 7-16-18 No. of pieces 6
Specification 49 S1d Grade B Estimated weight per piece 120
Date of first delivery 9-1-18 (To be ordered by Shop ordering the castings
Date of last delivery 8-15-18 in accordance with promised date of Completion
Pattern Status In the Loft V New Pattern In the Foundry
(Date of Completion)

Description	Heat No.	Date	No. Made	
Track Support (Front & Rear) Loading Device etc	E 188	7-30	2	

Blueprint No. 57834-A Piece No. 1 M. M.

FIG. 4—FOUNDRY SHOP ORDER—MOLDER'S COPY

STEEL FOUNDRY
MOLDING REPORT

Reported by S.A. HIGGS Date 7-28 1918

Core Check	Mold Check	Stub Number	Description	Bpt.	Pc	G T	No Made	Wt.	M P
None	178	ZE 13543	Track Support	57834	1	B	1	124	✓
None	178	R 764	5" B.M. Carrier	54774	1	B	1	167	✓
222A	141	U 401	Director Stand	55239	1	B	1	95	✓
None	151	U 109	Torpedo Door	40717	1	B	2	100	

Super. Molding F.S.S. Shift 8 to 4

FIG. 5—FORM FOR MOLDING PROGRESS REPORT

STEEL FOUNDRY
POURING REPORT

Reported by S.A. HIGGS Date 7-28 1918

Core Check	Mold Check	Stub Number	Description	Bpt	Pc.	G R	No. Made	Wt.	
None	178	ZE 13543	Track Support	57834	1	B	1	124	✓
None	178	R 764	5" B.M. Carrier	54774	1	B	1	167	✓
222A	141	U 401	Director Stand	55239	1	B	1	95	✓
None	151	U 109	Torpedo Door	40717	1	B	2	100	

Super. Dry Floor C.A.E. Shift 4 to 12 Metal held in ladle 8 Minutes

Poured by J.B.E. Melter SCOTT Heat No. E 185

FIG. 6—POURING REPORT

STEEL FOUNDRY—MOLDS POURED.

Heat No. E 185 Date, July 28, 1918

Furnace loss, 929 Pigs returned, 6623

Pig Iron 1	Pig Iron 2	Own Scrap	Foreign Scrap	Fe Mn	Fe Si	Wash Metal	Alum	Ore	Oyster Shells	Electrode	Total Melt
		2000	10500	100	270		4	400	240	1	13274

Stub No.	Molds Poured	Molder's Tag No.	Name of Piece	Grade	Bpt	Pc	Wt. of Castings	Wt. of Heads & Gates	Wt. of Defectives
ZE 13543	1	56092	Track Support	B	57834	1	124		
R 764	1	56092	5" B.M Carrier	B	54774	1	167		
U 401	1	56096	Director Stand	B	55239	1	95		
U 109	2	56126	Torpedo Door	B	40717	1	200		
							5722	6000	623

C Mn P S Si Cu Ni Cr
.20 .84 .023 .020 .19 .48 .50 Trace

FIG. 7—FINAL RECORD OF CASTINGS MADE FROM SINGLE HEAT

as previously mentioned, all the ordnance manufactured at the naval gun factory is made in accordance with navy department specifications, the foundry is instructed to make the castings on this order as outlined in the specifications for steel castings indicated by the characters 49*Sld*. The chemical and physical requirements for the various grades of metal included in these specifications are embodied in the accompanying table.

Supply Officer's Records

The first three columns of this form are filled in by the supply officer's clerk who makes entries on the record from information contained in molding and pouring reports. As the finished castings are delivered, the last five columns are filled by the shipping clerk. With each lot of castings delivered a supply officer's receipt is forwarded. This must be signed by the recipient and returned to the foundry when the number of the receipt and the name of the recipient are entered in the last two columns. The heading "Receipt No." over the next to the last column refers to this receipt. The supply officer's receipts are marked "partial" or "complete" to indicate to the recipient whether or not more castings are to be expected. It also furnishes the master mechanic of the machine shop with data to enter on his copy of the foundry shop order.

When the supply officer has made the proper entries from the receipt upon his foundry shop order, the receipt is sent to the accounting office. As these receipts are received by the accounting office, they are filed under the stub number of the subsidiary job order and when a receipt marked "complete" is finally received, the accountant is thus automatically informed that all the foundry work on the order is finished and proceeds at once to compute the costs. When the foundry costs have been determined, the charges are entered against the original job order, a copy of which is sent to the accounting office by the superintendent.

Time of Coremaker and Molder

In order to secure a record of the actual time spent by the coremaker and the molder upon any one casting, they are given copies of the foundry shop order which they use for reference in filling out their time cards. These time cards bear the foundry shop order serial number. As they are turned in, they are sent to the accounting office where the time is charged against the job. It is through this means that the direct labor costs are accurately determined

and properly charged. These same time cards also are used to compute the pay of the coremakers and molders.

The fifth copy of the foundry shop order is turned over to the foreman, who upon receiving it, places it on a file among other new work to be taken up. Once the job is started, this copy is transferred to a file of work under way. Through this means, the foreman knows precisely at all times the exact status of the work in his foundry.

For the information of the master mechanic of the machine shop a sixth copy of the foundry shop order is supplied for his files. It is on this copy that he enters the data from the supply officer's receipt. This copy not only shows when deliveries are in arrears, but also serves to indicate the number of castings he may expect for machining in the near future.

Report of Work in Progress

Fig. 5 shows the form which is used to secure data on molding in progress on the foundry floor. The record of each flask is identified with the foundry shop order by entering the serial number of the order in the column headed "Stub No." Further identification is contained in other columns which give a brief description of the casting, the blueprint and piece number, the grade of metal to be poured into the mold, and the number of castings in the flask. In the first column is entered the number of the coremaker whose cores are used in the flask. These numbers are scratched on the cores by the coremakers and are copied onto the moldings have been made from a heat.

Molders are given brass checks bearing numbers individual to each flask. Before the molds are baked, these checks are tacked on the flasks and their numbers are properly entered on the molding report. After the molds have been baked and are ready for pouring, reference to the brass checks and molding report shows the grade of metal from which the castings are to be made. As a heat is poured, the brass checks are removed from the flasks and sent to a clerk who checks the extreme right-hand column on the molding report. These checks show exactly what castings have been made from a single heat.

After a heat has been poured, the data concerning castings made from that heat are transferred from the molding report to a pouring report which is shown in Fig. 6. This pouring report constitutes a preliminary record of single heat and carries a heat number assigned by the

ELECTRIC FURNACE

	Expenditures
Date	7-28-18
Heat No.	E185
Pig Iron	
Silicon	270
Aluminum	4
Ferro Manganese	100
Iron Ore	400
Heads & Gates	2000
Nickel Shavings	
Monel New	
Monel Shavings	
Nickel Scrap	
Carbon Scrap	10500
Carbon Shavings	
Money Plata	
	Receipts
Good Castings	5722
Defective "	623
Heads & Gates	6000

FIG. 8—CHARGING RECORD FOR FURNACES

MELTER'S REPORT
ELECTRIC FURNACE NO. 1

DUNHART — MELTER — LANGLEY — 1ST HELPER

HEAT NO. E185
ORDER NO. R7305
DATE 7-28 1918

CHARGE AND ADDITIONS

	Weight
Foreign Scrap	10,500
Own Scrap	2,000
	400
	100
	270
	4
	13,274
(Open Hell)	240
	240

ANALYSIS

	C	Si	S	P	Mn	Ni	Cr	Va
Required	.28-.33	.30	under .05	under .05	.75-1.00			
Obtained	.20	.19	.020	.025	.84	.50	Trace	

PRELIMINARY TESTS

No.	Time Left	Time Reached	Time Held	Time Poured
1	4:20	4:40	:20	:20

TIME OF HEAT

Time		Min.	Min.
10:00	Previous Heat Tapped		
10:25	Began Charging		(25)
11:35	Finished Charging	1	10
11:40	Current On		05
3:00	Melted	3	20
3:30	Finished Slagging		30
4:50	Tapped	1	20
	Time of Heat	6	25

Current

Meter Reading Begin	965600
Meter Reading After Melt Down	969100
Meter Reading at Finish	970600
Total K.W.H.	5000
K.W.H. per Ton	757.5

Lining No. 2

Electrode No. 1 OK
Electrode No. 2 OK
Electrode No. 3 OK
Slag Conditions Normal
Previous Heat or Stock in Ladle OK
Previous Conditions of Working Good
Slag Stock Left in Working Quiet
Appearance of Working None
Previous Conditions of Fettling

PRODUCTION

No. Ingots	Size	Weight	Remarks

Date
Ladle Stock 200#
Metal
Loss
Total
Slag Weight

DELAYS AND CONDITIONS

Time Good
Metal Good
Furnace Good
Electrode Appearance OK
Working Appearance OK
Water Pressure OK

FIG. 9—RECORD OF EACH HEAT KEPT BY THE MELTING DEPARTMENT

W. O. F. 304.

REPORT OF ANNEALING.

Heat No. E 185 Furnace No. 2 Readings

Furnace fired 8.00 A.M. 8-1-18 Heat up 12.00 M. Temperature 1450°

At heat 3 hours. Closed 3.00 P.M. Cover removed 12.00 M. 8-2-18

Time cooling 21 hours. Relighted Temperature

Heat up Temperature At heat hours.

Closed Hours cooling Operator SMITH

REMARKS.

NO.	NOMENCLATURE.	HEAT NO.	NO.	NOMENCLATURE.	HEAT NO.
ZE 13543	Track Support	E 185			
R 764	5" B.M. Carrier	E 185			
U 401	Director Stand	E 185			
U 109	Torpedo Door	E 185			

FIG. 10—ANNEALER'S REPORT

furnace attendant. The molding and pouring reports are filed for foundry reference.

As soon as the pouring report is made out by the clerk, a copy is sent to the annealer. The annealer's copy is placed in his hands before the molds are taken to the sand pile. As the castings are knocked from the flasks, the annealer, or rather his helper, refers to his copy of the pouring report to identify the castings and stamps the heat number on them, thus assuring the identity of each casting with the heat from which it was poured.

Following Up Each Heat

The final record of castings made from a single heat is shown in Fig. 7. The descriptive data relative to the castings agree with that on the pouring report. In addition to these data are entered the constituents of the furnace charge constituting the heat. The "furnace loss" consists of the total weight of the charge less the total weight of the good castings and pigs returned. The weight of the heads and gates plus the weight of defectives gives the weight of "pigs returned." These data are sent to the foundry office by the supply officer who issues the raw materials. Duplicate copies of the steel foundry-molds poured report, Fig. 7, are distributed as follows: Foundry files, accounting office, inspector and shipping clerk.

The necessity for identifying each casting with the heat from which it is poured is twofold: The cost per pound of metal in the casting is dependent upon the cost of the materials which enter into the heat; for an intelligent analysis of the physical and chemical characteristics of test coupons taken from the castings, the inspector must know the exact constituents of the heat. As the furnaces are charged, a record is made out as shown in Fig. 8, on which is entered the weights of the raw materials in the charge, the number of the heat and the date. Separate records are kept for the electric furnace, the converter and the open-hearth furnace. These reports of materials charged are turned over to the supply officer who totals them for entry on a monthly report of charges into each furnace. At the end of the month, these reports are sent to the accounting office where the cost per pound of metal is computed. A memorandum of the constituents of each charge is sent to the foundry office where the data are noted on the record of castings made from a single heat as shown in Fig. 7.

In addition to making out a record of the constituents of each charge, the melting department also keeps a log of each heat which is forwarded to the inspector upon its conclusion. The method employed in keeping this log and the data recorded are readily understood by referring to Fig. 9 which is a record of a typical open-hearth furnace run.

Annealers Report in full

The influence of annealing upon the characteristics of steel castings is such an important factor that the annealer is required to furnish the inspector with an accurate account of the treatment of each casting. These data are entered on a form, Fig. 10, which lists the castings, their heat numbers, and the treatment to which they were subjected in the annealing furnace. Pyrometer readings taken during each run of the annealing furnace are sent to the inspector as a check on the data entered on the annealing furnace report, the test coupons are removed and sent to the machine shop to be prepared for the laboratory. The direct or labor cost of this machine work is sent to the accounting office to be charged against the foundry shop order.

Coupons taken from castings are tested in the physical and chemical laboratories to ascertain if the casting is in accordance with the specifications on the original order. The inspector accepts or rejects the castings and sends to the foundry for its information a report of the tests on a form similar to the one shown in Fig. 11. If the laboratory tests

W. O. F. 292

TEST OF Track Support File No. 21792

Castings / ~~Forging~~ Grade B Specification No. 49 Sld. Stub No. ZE 13543

Heat No. E 185 ~~Ingot No.~~ / ~~Billet No.~~ Job Order No. 8-2-38165

Drawing No. 57834 Pc 1 Call No. Requisition No.

	CHEMICAL ANALYSIS								HEAT TREATMENT
	C	Si	P	S	Mn	Cu	Ni	Cr	Annealing
Gov't Requirement									Temp. of Soaking 1450°
Contractor									Hours of Soaking 3
Government	.20	.19	.023	.020	.84	.48	.50	Trace	Hours to come up 4
									Hours Cooling 21

Date	Heat No.	Size of bar	Yield Point	Tensile strength, pounds per square inch	Per cent of elongation	Per cent of reduction	Rupture stress, pounds per square inch	Cold bend	Fracture	Remarks
8-15-18	— —		45% of T.S.	60,000	22	30.0		120°		
Requirements	E 185	0.50	40,100	68,200	23.5	34.8		120° Cup ½		OK

FIG. 11—INSPECTOR'S REPORT

of the coupons prove unsatisfactory, the history of the metal may be traced through the log of the furnace, the steel foundry-molds poured report, and the annealer's report which the inspector has in his office. If further investigation is desired the names of the molder and the coremaker and any other desired information can be obtained from the molding and pouring record.

A resume of the foregoing shows the data furnished the accounting office for compounding the cost per pound of the castings. Direct labor costs are figured from the time cards of the coremakers, the molders, the cleaners and others whose work is directly associated with the production of the castings. These cards bear the number of the subsidiary or foundry shop order and give the actual number of hours of labor as previously explained. Costs of material are computed from the records of materials charged into the furnace which are furnished by the supply officer. Accurate account of materials and supplies used in the foundry which do not enter directly into the castings, such as oil fuel, furnace brick, etc., and indirect labor costs, such as floor cleaning, crane operation, etc., is kept through copies of requisitions for supplies and time cards which are sent to the accounting office from the foundry. Other indirect charges such as depreciation of the building and tools, and equipment maintenance and replacement are combined and proportioned equitably in conjunction with the direct charges for labor and material in determining the final cost per pound of the casting ready for delivery.

Selecting the Best Brush for Foundry Work

By J D Coleman

BRUSHES for foundry use ordinarily are made of bristles, hair or of wire. The common hard and soft brushes are made of bristles or hair. Bristles come from all over the world and the pig or boar is the producer. Hair comes from almost every locality and the horse is the greatest producer. Both bristles and hair come from either live or dead animals, but the bristles from living animals are the best.

A bristle varies in size from the larger butt or animal end, to the smaller flag or outer end. Furthermore, the bristle is not smooth; under the microscope the rough, file surface can be seen and by running the fingers over the bristle, this roughness can also be felt.

The hair is the same size from end to end and has a smooth, clean surface which can be proven easily by running the hair through the fingers.

The horsehair used comes from the tail and mane; the hair from the tail being stiffer, is used for hard brushes and the hair from the mane, being softer, is used for soft brushes.

Bristles, having a rough surface, are liable to become clogged with dirt, and therefore they become less effective with use. Also, as the bristle is thicker at the butt end, the soft brush made of bristles becomes stiffer as it wears. Hair being smooth and of uniform size, stays clean easier and becomes stiffer as it wears. Therefore, a hair soft brush remains in use longer as a soft brush, than a bristle brush.

The best bristles come from the Russian wild boars. This grade of Russian bristles is called Okatka and because of the high cost, is used almost entirely for making painters' brushes.

The next grade of bristles come from China, from the large black Chinese hog which is killed for its bristles. This grade of bristles is just as good for foundry brushes and is much cheaper, costing about one quarter of the Okatka.

The third grade comes from the dead pigs of India, coming in grays and blacks and are graded as extra stiff, stiff, medium and soft. There is no difference in quality due to color, the gray being used to imitate the Okatka and only an expert can tell the difference.

The fourth grade is known as the Spitz bristle and the Spitz-Spitz bristle. This grade comes from Spitzenburg, through the German bristle market; it comes from the wild boar and is straw or golden in color. The Spitz is a soft bristle and the Spitz-Spitz is the hard variety.

The fifth grade of bristle comes from the French, native dead hog and is nearly white or has a pale straw tinge. The butts are very stiff and the flags very soft.

The sixth grade is known as the American drag bristle. It comes from the dead hog and is dragged out by scrapers. Nearly always some of the flesh comes with the bristles. The bristles are short, rarely over 3½ inches long and average about 2½ inches. They are used in set work, where the bristles are pitched-in as they are too short to draw in and turn.

The best hair comes from the Normandy horses. These horses are kept clean and in good condition. The next grade of hair comes from South American horses. Horse hair is black, gray and white.

There is no difference in quality, the difference in price being caused by the demand for colors for certain purposes.

It is the prevailing opinion that hair brushes are best adapted for foundry work, the tail hair being used for the hard brushes and the mane hair for the soft brushes. The hair, soft brush will wear down two-thirds before it becomes too stiff to use as a soft brush.

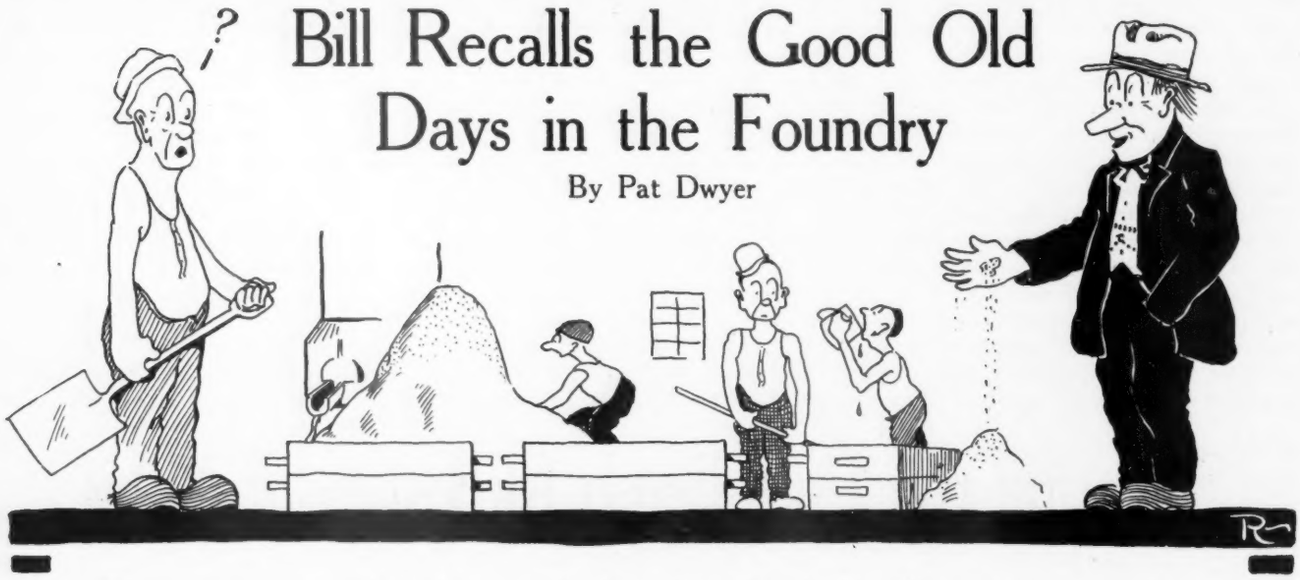
Mounting the brushes is another factor of importance. Three methods ordinarily are employed. One method consists of boring holes in a block and setting the bristles with pitch. Another method consists of boring holes in a block and driving in the knots on the bristles with staples to the bottoms of the holes. Both of these methods take a solid block.

The best method is to draw the bristles into holes in the block with brass wire. All the knots are connected. The argument against this form of fastening is that if one knot breaks the wire fastening the bristles will work loose, but the result of long experience among brush makers and brush users indicates that this rarely happens in a brush made by a skilled mechanic. The wire-drawn type of brush requires a back which may be fastened to the block with screws, nails or glue. The best block is made of hard maple and the back of white or a similar grade of wood. The best fastening of back to block is effected with screws.

Normandy horse hair brushes for both soft and hard types, are economical for foundry use. Hair from the mane is used for the soft brushes and from the tail for the hard brushes. These should be wire-drawn in hardwood blocks, with soft backs, screwed together. The best grade of bristles are too expensive for foundry work and their life does not warrant the expense. Black China, wire-drawn bristle brushes render good service and are economical to use for cleaning core boxes.

Bill Recalls the Good Old Days in the Foundry

By Pat Dwyer



DID you ever go to work in the morning and find that neither the furnaceman nor his understudy was on the job? Aha! I thought so; you have all been there more or less frequently during the past few years. Time was, when the furnaceman missed a day, it did not make much difference. The foreman either would run the cupola himself, or he would send one of the molders to the charging floor. Those were the good old days; any man in the shop could turn his hand to any of the jobs—molding, coremaking, chipping or furnace tending. It may be that they could not calculate the silicon content to within three decimal places, nor could they measure the cubical contents of a pattern; but they could break a pig and judge of its quality and fitness for the work, and they could look at a pattern and tell you within a very few pounds how much the casting would weigh.

Now, it is different. If the furnaceman fails to show up, the foreman who is still the goat, takes off his coat and vest, lays aside his fountain pen and other insignia of office, and not only must show some laborer how to do it, but he must do most of it himself. I suppose this state of affairs is due to our latter-day efficiency—every man a specialist. In olden times, when a boy served his apprenticeship, it was considered as much a part of his trade to learn how to melt iron as it was to learn how to make molds to receive it. But now the business has been divided and subdivided to such an extent, that all the average boy learns is one branch of it; and the discouraging feature of it is, that the average boy seems perfectly satisfied with that. In fact, he goes further, for after he has become fairly proficient at one branch, he is apt to become quite *chesty* and is willing and even anxious to proclaim to one and all that he is a molder. He does not know how the iron is melted, and seems to care less, just as long as he gets it hot and, if possible, gets the first iron every night.

The Molders Were Sights

I was standing in front of the cupola the other day in a graceful attitude, somewhat soiled and ragged-looking about the pants to be sure, but still the attitude was graceful—posture No. 6 on the Swedish Exercise Chart, to be exact—thinking over these things, when the door at the end of the shop opened and in came my old friend Bill. He sauntered slowly up the gangway taking in the sights, and believe me, some of the molders *were* sights. Some with one brace holding up their pants and others trusting to Providence, with no braces at all, and faith, some of them with breeches that were not worth putting braces on. I have often wondered at this peculiar trait among molders and foundrymen generally; meet them on the street or anywhere outside and they are the classiest dressers in town, but in the shop, oh Boy! It is certainly no place for a lady.

Bill reached into one of the sandheaps and picked up a handful of sand, squeezed it in a professional manner, then opened his hand, looked at the ball and threw it away.

"Pretty good stuff, that," said he, "but very open; I guess you use lots of gaggers, eh?"

I said, "Yes, most of our work is pretty chunky stuff and the firm does not like to see scabs on the castings."

I then politely asked him to what I was indebted for the honor and pleasure of his visit and he told me that one of his men was buried that day, and the shop had knocked off for the funeral.

"Funny thing, that," said Bill. "That was the first dead molder I ever saw. I was always a firm believer in the foundry tradition that molders never die. They just disappear. You remember when we were kids in the old shop and Bill Brown who made the engine beds used to solemnly assure us, that no one ever saw a dead molder or a dead donkey. That's the way, as you grow older, one by one all the old foundry traditions get the

THE APPRENTICE IS APT TO BECOME QUITE CHESTY

props knocked from under them. That is, provided that you are not one of those pigheaded wise men who knows it all when he is about 20, and who can't be convinced that *the world do move.*

"I have had quite a wide and varied experience, still I realize that I am only an ordinary human being and, therefore, cannot know everything. For that reason I read all the foundry literature I can get, talk to every foundryman who will stand for it and try as many experiments in the shop as I can get away with. I encourage every man who works with me to tell me his ideas and I am as genuinely pleased to get a good one and adopt it, as if I had invented it myself. A man who has never tried this plan will be surprised at the number of shop kinks picked up in this way. I don't mean by this that one ought to adopt every hair-brained plan that is put up to him. Is is a simple matter for a practical man, with an open, unbaised mind, to decide whether an idea is workable or not.

"There are extremes in everything, and I don't know which is the more aggravating type of man to work for, the hide-bound fossil who will adopt nothing new, or the smart young fellow who thinks he is a born executive and because he made a success of running a machine shop, or a laundry, or something else, that he would make an ideal foundry superintendent. I have worked for both kinds, very limited engagements, 'tis true, for I can't work for a man I don't like; and left them with feelings which no Christian ought to entertain for his fellowman. For instance, I told the first type that his furnace practice was not up to the mark, his charges were too light, and I proposed to practically double them. Did he fall on my neck and tell me to go to it and save him about a ton of coke every heat? He did not. He said, 'Nonsense, we are getting satisfactory iron out of the furnace with our present practice and you had better leave well enough alone.'

"I left well enough alone and left him, too. I believe the other type was even worse.

"Listen! A certain shop had been on a strike for a year; then they signed an armistice. The foreman and most of the men had been scattered to the four winds, so the manager conceived the brilliant plan of taking the machine shop foreman and making him foundry superintendent. Things did not appear to go very well, so they decided that they needed a practical man for a foreman. My unlucky star being then in the ascendant, I fell for the offer. But, aals, and alack, also gol-ding it, I soon realized that I would soon be hitting the ties again. The shop was right up to the minute in equipment, air rammers and everything.

"I had a man making open sand plates one day. He had leveled up his straight edges, filled in the sand, and he and a helper were striking-off the bed with the transverse straight edge when our hero came along. 'Here,' said he to me, 'this won't do at all. This shop is equipped with air rammers and here you have two men wasting their time flattening off a bed with a little narrow straight edge. Send the molder to do something else, and let the helper take one of these air rammers and butt-off that bed. The air equipment in this shop represents quite an investment and I am not going to have it stand idle.'

" 'Good night,' says I, 'you may be able to make an open sand bed with an air rammer, but I am young at the game and I am scared to try it, and I bet you will be scared when you come to pour it.' I did not wait to see the fun and never heard whether he burned the shop down or not, but I hope he did. I have a job now that just suits me. When I hired on, the boss said, 'Go as far as you like, make any improvement or changes that look good to you. If your monthly report shows a gain I will raise your wages, if it does not, I will fire you so sudden it will make your head swim.' 'Fair enough,' I said, and started in. I have had my pay raised twice a year ever since I went there.

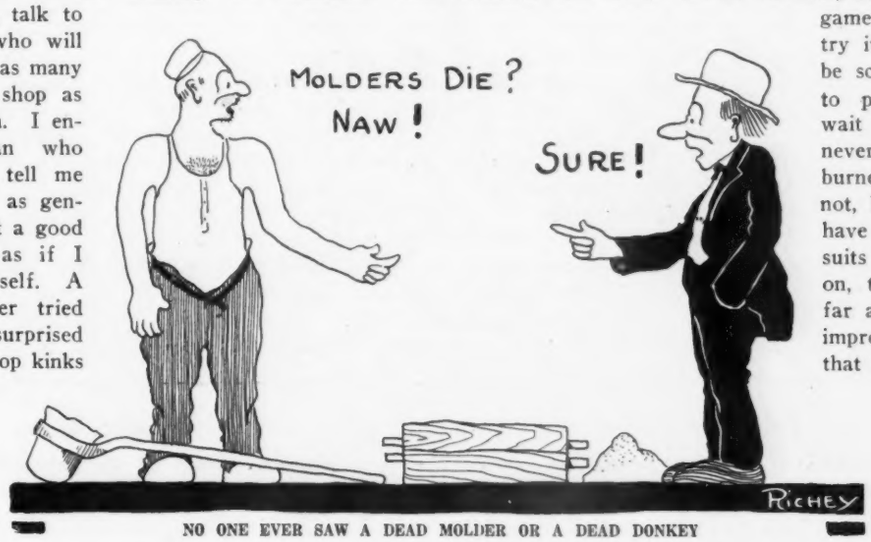
"By the way, what size is your cupola inside and what weight charges do you use?"

I told him 30 inches and I use 1800 pounds to a charge.

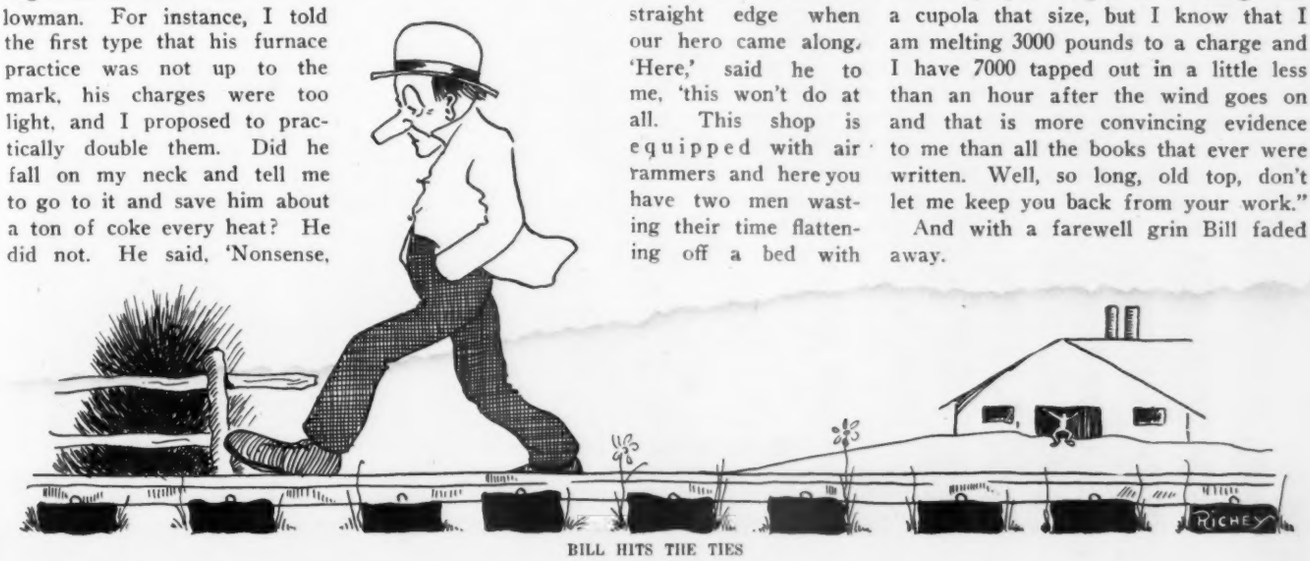
"You are wasting coke," said he. "I have a 30-inch cupola and charge 500 pounds of coke and 3000 pounds of iron on the first charge, and 200 pounds of coke and 2000 pounds of iron on each succeeding charge.

"You may not believe it, but come over any day and I'll show you. I know all the books on foundry practice recommend from 1500 to 1800 pounds as the proper weight of a charge for a cupola that size, but I know that I am melting 3000 pounds to a charge and I have 7000 tapped out in a little less than an hour after the wind goes on and that is more convincing evidence to me than all the books that ever were written. Well, so long, old top, don't let me keep you back from your work."

And with a farewell grin Bill faded away.



NO ONE EVER SAW A DEAD MOLDER OR A DEAD DONKEY



BILL HITS THE TIES

Lubricating the Cylinders of Air Compressors

Tables and Explanations Are Given Showing the Advantages of Different Oils and Their Behavior in Air Compressor Work

By H V Conrad

SATISFACTORY lubrication of air-compressor cylinders is attained by reducing friction and carbonization of oil as far as possible. To reduce friction, the oil should have sufficient body to sustain the weight of moving parts and to form a seal between the piston rings and the cylinder walls. However, it should not absorb excessive power in overcoming the viscosity of the oil itself.

Carbonization of oil produces deposits of carbon which are sticky in the early stages of their formation and hard and flinty later. Such deposits occur on the valves, in the cylinder passages, in the pipes and eventually in the air receiver. Sticking or partial closing of valves and their consequent failure to act properly probably is the chief objection to carbon from the standpoint of the efficient operation of the compressor.

Causes of Carbon

The formation of excessive carbon deposits is due to one or more of the following causes:

The ill-advised use of oil, such as a steam cylinder, which easily decomposes in the heat of the air cylinder.

The use of oils of too great viscosity—commonly referred to as "heavy oils." These do not atomize readily and, therefore, remain too long upon the hot cylinder walls, baking down to sticky carbon deposits.

The use of too great quantities of oil which has the same effect as the use of too heavy oil as far as the carbonization is concerned.

The failure to provide a proper screen over the air intake of the compressor. Screens prevent the free entrance of dangerous dust or grit.

Abstracted from a paper based on the studies of the technical committee of the Compressed Air Society. The author, H. V. Conrad, is a mechanical engineer and is secretary of the New York section of the society.

For average normal conditions, air compressor or cylinder oil should be a medium bodied pure mineral oil of the highest quality, not compounded with fixed oils such as animal or vegetable. It should be carefully filtered in the final processes of manufacture. A wide range of composition is permissable for lubricants approved for this work, but a distinction must be made between those oils having a parraffin base and those having an asphaltic base.

From an operating standpoint there is no distinction between these two classes of lubricants, provided both have been properly filtered in the process of manufacture to remove the carbon-forming elements. If any carbon is formed, however, that deposited by the asphaltic base oils is of a light fluffy nature, whereas, that deposited by the paraffin base oil is adhesive and characterized by the hard, flinty nature.

As a guide to aid in specifying the qualities to be possessed by an air cylinder lubricant recommended for average duty, Table I is presented.

It is suggested that those oils within the range expressed by the minimum figures be used for light duty low pressure and temperatures, while those expressed by maximum figures should be used for those having high pressures and high temperatures.

Low pressure is understood to include those up to 100 pounds capacity which may be either small size, single stage units, or larger size, compound machines. High pressure compressors are those which are constructed with the proper number of stages so that no excessive temperatures are ever reached. The following table gives the cylinder temperature at the end of the compression stroke for single stage and compound compression, computed on a basis of free air entering at 60 degrees Fahr.:

Air compression lbs. gage:	Final temperature single stage, deg. Fahr.	Final temperature two stage, deg. Fahr.
10	145	...
20	207	...
30	255	...
40	302	...
50	339	188
60	375	203
70	405	214
80	432	224
90	459	234
100	485	243
110	507	250
120	529	257
130	550	265
140	570	272
150	589	279
200	672	309
250	749	331

As a guide for the selection of suitable asphaltic-base oils, Table II is given.

The quantity of lubricating oil to

(*Concluded on page 226*)

Table I

Physical Tests of Paraffin Base Oils

	Minimum	Average	Maximum
Gravity, Baume....	28 to 32 deg.	25 to 30 deg.	25 to 27 deg.
Flash point, open cup.	375 to 400 deg. Fahr.	400 to 425 deg. Fahr.	425 to 500 deg. Fahr.
Fire	425 to 450 deg. Fahr.	450 to 475 deg. Fahr.	475 to 575 deg. Fahr.
Viscosity (Saybolt) at 100 deg. Fahr.	120 to 180 sec.	230 to 315 sec.	to 1500 sec.
Color	Yellowish	Reddish	Dark Red to Green
Congealing pt. (pour test deg. Fahr.).	20 to 25 deg. Fahr.	30 deg. Fahr.	35 to 45 deg. Fahr.

Table II

Physical Tests of Asphaltic Base Oils

	Minimum	Average	Maximum
Gravity, Baume....	20-22 deg.	19.8-21 deg.	19.5-20.5 deg.
Flash point, open cup.	305-325 deg. Fahr.	315-335 deg. Fahr.	330-375 deg. Fahr.
Fire	360-380 deg. Fahr.	370-400 deg. Fahr.	385-440 deg. Fahr.
Viscosity (Saybolt) at 100 deg. Fahr.	175-225 sec.	275-325 sec.	475-750 sec.
Color	Pale yellow	Pale yellow	Pale yellow
Congealing pt. (pour test)	0 deg. Fahr.	—0 deg. Fahr.	—0 deg. Fahr.

Table III

Quantity of Air Cylinder Lubricant Required per 10 Hour Day

Diameter of cylinder, inches	Size of cylinder, inches	Displacement per min. cu. ft.	Piston speed ft. per min.	Sq. ft. of cylinder wall swept by piston	Drops oil per min.	Drops oil per 10 hrs.	Sq. ft. oiled per drop	Number pints oil required per 10 hrs.
8	8 x 8	120	344	718	1	600	718	0.0375
12	12 x 12	320	408	1230	2	1200	613	0.0750
18	18 x 18	880	496	2340	4	2400	585	0.1500
24	24 x 24	1730	550	3450	6	3600	575	0.2250
30	30 x 30	2940	600	4700	8	4800	590	0.3000
36	36 x 36	4550	644	6070	10	6000	607	0.3750
42	42 x 42	6700	696	7600	12	7200	633	0.4500

Metallography Applied to Nonferrous Metals—II

The Intricacies of the Equilibrium Diagrams Are Explained and Their Application to Nonferrous Casting Manufacture is Pointed Out

By Ernest J Davis

TO be able to predict the microstructure of any series of alloys and to follow the changes which these alloys may pass through in cooling from the liquid to the solid state, it is necessary to have some knowledge of the equilibrium diagram of the series to which the alloy belongs. These diagrams are plotted on the results of extensive thermal and microscopic investigation, and to simplify matters we will follow through a series of imaginary alloys of the metals *X* and *Z* in which we get a eutectic and two solid solutions, one of the simplest types.

Fig. 1 is the diagram representing this series. These diagrams are prepared by taking alloys of the metal *X* with increasing proportions of the metal *Z*, and determining the freezing points of each alloy; the freezing points then are plotted against the percentage composition and a diagram, as shown is obtained. The curve *A C B* is known as the *liquidus* above which all alloys are liquid; the curve *A D C E B* is known as the *solidus* below which all alloys are solid, and the horizontal line *D E* is the *eutectic* line. The vertical lines *Dd* and *Ee* are the limits of the solid solutions and are placed microscopically.

Following Alloys From Fusion

To make understanding of the diagrams clearer, we will follow a few alloys from fusion. For example, we will take an alloy of composition *Y* and allow it to cool from the molten state. Nothing happens, that is, uniform cooling takes place until the liquidus *A C B* is crossed at the temperature of *c*, when crystals of the metal *X* begin to be deposited, and at the same time the mother liquor becomes richer in the metal *Z*. As the temperature falls, more of the crystals *X* are deposited, while

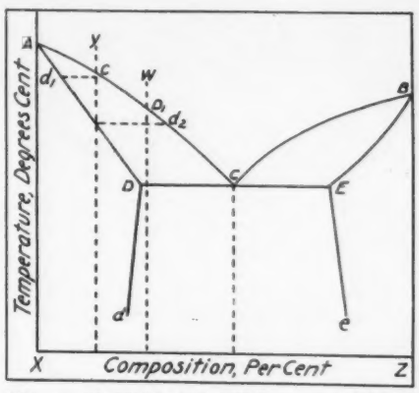


FIG. 1—DIAGRAM OF SERIES OF IMAGINARY ALLOYS

the mother liquor becomes progressively richer and richer in the metal *Z*, until the solidus *A D E B* is crossed, when the remaining liquid solidifies as a whole, and microscopically we obtain a solid solution. An alloy of this type, when examined under the microscope, often shows what is termed a *cored* structure, examples of which appear in Figs. 2 and 4. The explanation of such a structure is that the crystals first deposited have the composition of *d* but not of *c*, Fig. 1, and those deposited

FIG. 3—COPPER-ZINC ALPHA SOLUTION, TWINNED STRUCTURE. MAGNIFIED 100 DIAMETERS

last have a composition d_2, and as equilibrium can only be obtained by the process of diffusion, which is extremely slow in rigid bodies, it will readily be seen that if specially slow cooling is not resorted to, the interior of the crystals will have a different composition from the exterior, and the structure shown is obtained. Now take an alloy of composition *W*; crystals of *X* commence to separate at D_1 and as the temperature falls the mother liquor becomes richer and richer, just as in the case of the alloy of composition *Y*, and finally is solidified at the eutectic temperature. The microstructure consists of crystals of *X* surrounded by the eutectic *X Z*. An alloy of composition *C* solidifies at a constant temperature, and the structure consists wholly of eutectic. Alloys with compositions to the other side of the point *C* behave in exactly the same way, with the exception that the crystals of the metal *Z* are the first to separate in cooling.

Although conditions of equilibrium seldom if ever exist in the foundry, great help can be obtained by the knowledge of the structural changes which take place in the alloys one may be using, even though one may not be working under the ideal conditions. As an example, several cases could be quoted where quenching from above the transformation temperature has a profound influence on the mechanical properties and hardness. This phenomenon is well known in steel, and is also exhibited in certain of the alloys of copper and tin (bronzes).

Copper-Zinc Series, Brass

We will now consider the alloys of copper and zinc. Fig. 14 is a reproduction of the equilibrium diagram of these alloys as worked out by Shepard, with the modification of Professor Carpenter.

The liquidus consists of six branches. There are no well defined maximum points which would indicate the formation of chemical compounds, although claim has been made for them. The

FIG. 2—COPPER-TIN ALPHA SOLUTION, CORED STRUCTURE. MAGNIFIED 100 DIAMETERS

FIG. 4—COPPER-NICKEL SOLID SOLUTION, CORED STRUCTURE. MAGNIFIED 100 DIAMETERS

diagram shows in all six phases, but we shall confine ourselves to the first three, namely, those denoted by the letters α (alpha), β (beta) and γ (gamma). The alpha phase, the first constituent that forms when zinc is added to copper, is a solid solution and contains up to 37 per cent of zinc. The position of the point b in the diagram fixes the limiting composition of alloys which in all circumstances contain only the alpha phase. This alpha solid solution very often exhibits a cored structure which may be removed by annealing or mechanical work. Most alpha solid solutions show a marked characteristic, namely, that of twinning. Fig. 3 shows the twinning of a 70-30 brass.

This twinning is the swinging round, as it were, of a parallel band of the crystal, produced by mechanical work and annealing. Alloys containing from 30 to 37 per cent of zinc show the existence of a new constituent, namely β (beta). In cooling alloys in this range, alpha separates out until a temperature of about 880 degrees Cent. is reached, when the remaining liquid solidifies, forming the beta phase. Owing to the shape of the line b c, Fig. 14, these alloys pass from a region in which both alpha and beta can exist side by side into a region where alpha only is stable and where, therefore, beta can only exist by rapid cooling. The alpha phase is a comparatively soft and ductile body, which can be easily worked in the cold, while the beta constituent is much stronger, harder and much less ductile, and its presence in an alloy is at once felt by a decided decrease in the ductility, increase in strength and hardness and greater difficulty in cold working.

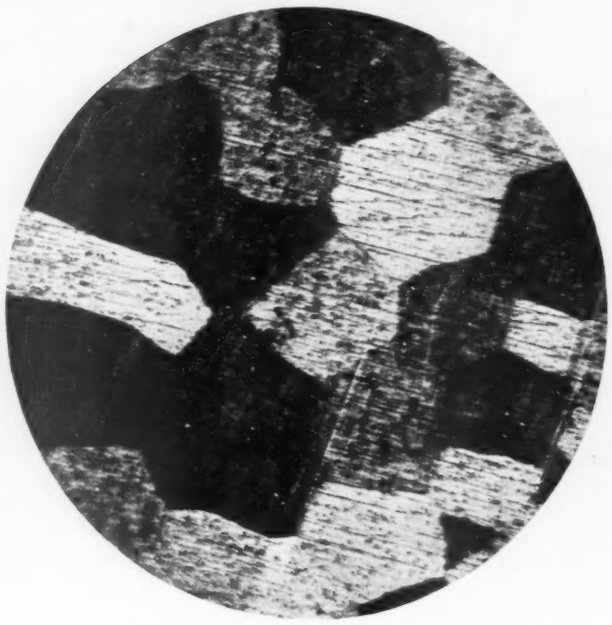


FIG. 6—COPPER-ZINC BETA SOLID SOLUTION; MAGNIFIED 100 DIAMETERS

When the percentage of zinc exceeds 37, the beta phase remains stable at all temperatures down to 470 degrees Cent. and slowly cooled alloys show a duplex structure containing both the alpha and beta phases side by side. Figs. 5 and 7 show typical alpha-beta structures. Rapid cooling affects the structure of these alloys by increasing the proportion of beta stable at the ordinary temperatures. The effect of quenching is felt more near the alpha end, gradually diminishing toward the center of the range and increasing again toward the beta end. Rapid cooling from a temperature above B C suppresses the beta to alpha change and the alloy results in a homogeneous beta solid solution, Fig. 6. It is the ratio of the alpha and beta phases that determines the strength of these alloys; alloys toward the alpha end of the range giving a comparatively low tensile stress with a high elongation, while towards the beta end we get the reverse, a high tensile stress and less elongation. As will be noted from the foregoing, this ratio can be altered in almost all the alloys by suitable heat treatment. It is here where the equilibrium diagram is of considerable use to the foundryman, as we can readily get the temperature at which the ratio of the alpha to beta can be suitably altered.

The region of true stability of the beta phase, according to Professor Carpenter, is confined to temperatures above 470 degrees Cent. At this temperature heat evolutions in the cooling curves occur, which Professor Carpenter considers, together with his microscopical results, to indicate the decomposition of the beta phase into alpha and gamma. This splitting up of the beta phase is extremely slow and is not readily seen under the microscope, especially in pure copper-zinc alloys. How far the decomposition of the beta phase affects the mechanical properties of these alloys is not yet known, although previously it has been suggested as a cause of spontaneous cracking, but there is no direct evidence that this is the case and a good deal more work is required to be done before this is verified. It has already been mentioned that the beta phase can be worked in the cold; it also lends itself to hot rolling and stamping, while the wholly alpha alloys are not readily worked hot. At the ordinary temperatures, the alloys between A and c, Fig. 14, appear to consist of alpha plus beta while those between c_1 and d_2 consist of beta plus gamma. This later phase is hard and brittle and its presence in alloys renders them unfit for any purpose where strength and toughness are required.

The usefulness of the copper-zinc alloys for certain purposes is increased by the addition of one or more other elements. The most usually added elements are aluminum, manganese, iron, tin and lead; the so-called manganese bronze contains most of these metals. From the microscopic point of view each of these elements behave in much the same way, that is, the added metal dissolves in one or the other of the constituents, probably the alpha solid solution, up to a certain limiting proportion. Above this limiting amount a new constituent is formed which usually is hard and brittle so that a third metal in sufficient quantity has a deleterious effect. The foregoing elements also are capable of replacing zinc, that is, they

FIG. 5—COPPER-ZINC ALPHA AND BETA, 50 PER CENT ALPHA; MAGNIFIED 100 DIAMETERS. ALPHA WHITE

FIG. 7—COPPER-ZINC ALPHA AND BETA, 35 PER CENT ALPHA; MAGNIFIED 100 DIAMETERS. ALPHA WHITE

give a particular brass the appearance of containing more zinc than it really does. The zinc equivalents of the foregoing elements have been worked out and according to Professor Desch are as follows: Aluminum, 6; tin, 2; manganese, 0.5; iron, 0.9, and lead, 1. From the analysis of the alloy and by a simple calculation from the above equivalents the apparent or *fictitious* zinc is found. Bronze, as is well known, is an alloy of copper and tin. The diagram, Fig. 15, is the equilibrium diagram for the copper-tin series and is very much more complex than that of the copper-zinc alloys and parts are still in the controversial stage. As is usually the case the most useful alloys occur at one end of the diagram; in this case alloys containing more than 20 per cent of tin are not used extensively. The first constituent to appear when tin is added to copper is the alpha solid solution and alloys up to 12 per cent of tin consist wholly of the alpha phase. The copper-tin and the copper-zinc alpha phases are very much alike; in fact all solid solutions have similar microstructures. When rapidly cooled, the copper-tin alpha exhibits a dendritic structure characteristic of solid solutions which have not attained equilibrium, but slow cooling, or subsequent annealing equalizes the difference in composition which exists between the interior and exterior of the crystals and results in the uniform crystalline aggregate with which we are already familiar. In alloys with more than 12 per cent of tin, we find a new constituent appearing, namely, delta, Fig. 8. The delta phase is hard and brittle, but is only stable up to about 500 degrees Cent., where it is transformed into the beta phase, which is much more reasonable in its mechanical properties. The alloys richer in tin, particularly those covering the more complex part of the diagram, containing 20 to 40 per cent of tin, are of little industrial use, and will not be discussed. The alloys of copper and tin, which have been put to practical use may be divided into several groups.

FIG. 9—COPPER-TIN-PHOSPHORUS, SHOWING PHOSPHIDE FRINGE AROUND THE EUTECTOID; MAGNIFIED 700 DIAMETERS

Coinage Bronze

Coinage bronze contains from 4 to 8 per cent of tin and includes the alloys used for the so-called copper money and medals. It is sufficiently hard and tough to resist considerable wear and malleable enough to be stamped to shape. These alloys can be rolled, stamped and drawn either hot or cold, their microstructure being that of the alpha solid solution which very often shows characteristic twins.

Gun metal contains from 8 to 12 per cent of tin and was the metal used for ordnance in former days. Gun metal is largely employed for mechanical purposes where strong castings are required. Zinc is sometimes added and makes the alloy more fluid, gives sounder castings and somewhat softens the alloy; lead has been used for this latter purpose, but it is not always a desirable constitutent. The microstructure of gun metal varies according to the amount of tin present; the lowest members may consist of the alpha phase, while those containing higher percentages of tin will contain varying amounts of the delta phase which if quenched from above 500 degrees Cent. will become beta. It might be mentioned here that the effect of the addition of other elements to the copper-tin alloys somewhat resembles the addition of other elements to the alloys of copper and zinc and according to L. Guillet, *Revue de metallurgie,* Vol. VII, pp. 429-432 and L. Revellon, by adding zinc to alloys of copper and tin the zinc replaces a portion of the tin and the alloys have the appearance microscopically as if they contain a higher percentage of tin. These two French investigators estimated the coefficient of equivalence by the same method as that used to ascertain equivalence of the metals added in the copper-zinc series. Thus, in any one sample there may be obtained by chemical analysis the real figure while another or fictitious figure may be obtained by microscopic examination on observing the areas occupied by the constituent delta and carefully measuring them and converting them into a percentage of the whole field. The coefficient of equivalence sought can then be obtained by the following formula:

$$c\ f = 1 + \frac{(A - A^1)\ 100}{q\ A^1}$$

where A is actual percentage of copper.

A^1 = the fictitious percentage of copper.

Q = the amount of zinc found by analysis.

The formula has been challenged lately by F. Johnson, *Journal of Institute of Metals,* No. 2, 1918, as it is not in accordance with the equilibrium diagram for the copper-tin-zinc alloys by L. Hoyt and it will be seen from the three microphotographs, Figs. 10, 11 and 13, from some experiments by the authors, that the foregoing does not fit in with the facts.

Bearing bronzes contain from 12 to 16 per cent of tin, and often from 2 to 4 per cent of the copper is replaced by zinc, lead sometimes being included in

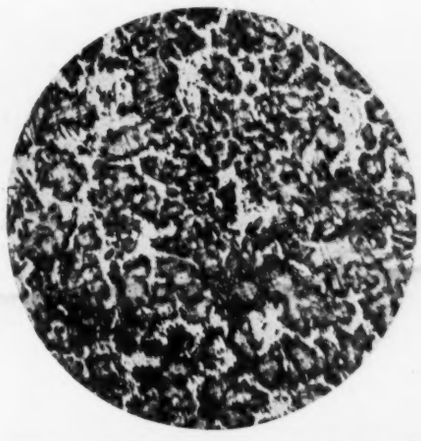


FIG. 8—COPPER-TIN ALPHA AND DELTA, MAGNIFIED 100 DIAMETERS. DELTA WHITE

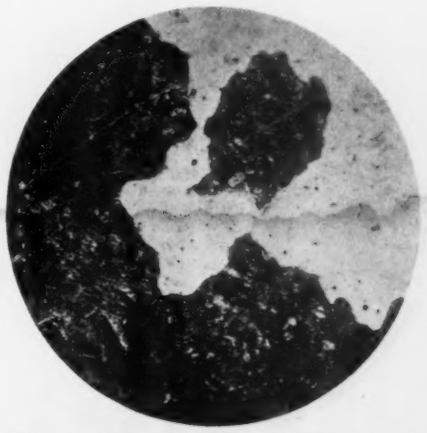


FIG. 10—COPPER-TIN, 10 PER CENT OF TIN. HOMOGENEOUS ALPHA SOLID SOLUTION; MAGNIFIED 50 DIAMETERS

FIG. 11—COPPER-TIN-ZINC, 8 PER CENT TIN AND 2 PER CENT ZINC. HOMOGENEOUS SOLUTION, MAGNIFIED 50 DIAMETERS

the mixture. The appearance under the microscope of these alloys is similar to the higher members of the gun metal series and their structure usually consists of the alpha solid solution surrounded

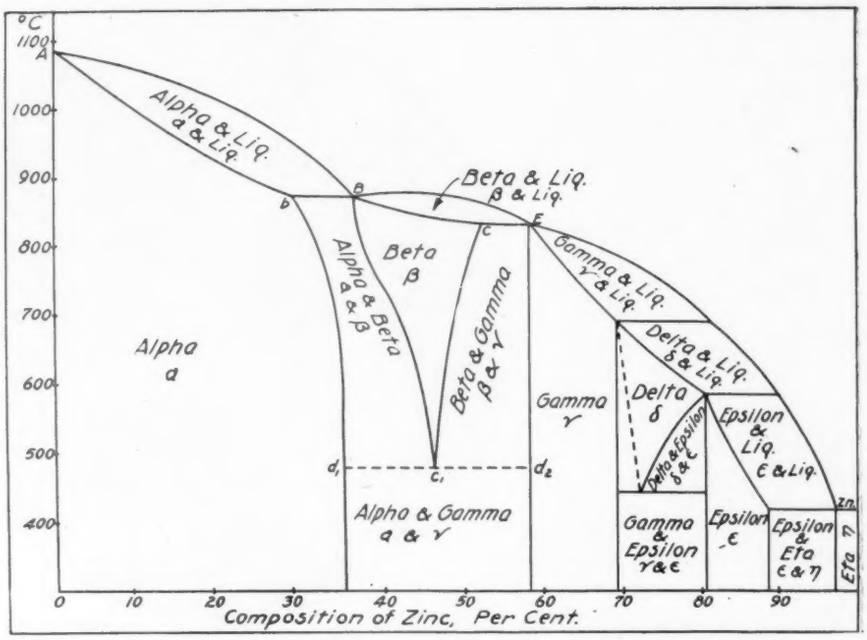


FIG. 14—EQUILIBRIUM DIAGRAM OF COPPER AND ZINC ALLOYS, BY SHEPARD

FIG. 12—COPPER-TIN, SHOWING DRAWING OUT OF EUTECTOID; MAGNIFIED 100 DIAMETERS

by crystals of the alpha plus delta eutectoid, the amount of course depending upon the composition.

Phosphorus is sometimes added to these alloys and when present in any quantity forms a hard and brittle compound of copper and phosphorus (Cu_3P) which is usually seen under the microscope as a fringe around the grains of the alpha plus delta eutectoid. Considerable difficulty is sometimes experienced in the foundry with these phosphor-bronzes, especially in regard to porosity. If one examines a porous sample of phosphor-bronze, he sees that the eutectoid has been drawn or squeezed out from between the crystals and has left voids through which the castings leak. Now the phosphorus rich eutectoid remains liquid some time after the rest of the metal has solidified and consequently is used to take up the contraction and thereby leaves minute holes in the castings, Fig. 12. The only real satisfactory remedy for this difficulty is to chill-cast.

FIG. 13—COPPER-TIN-ZINC, 5 PER CENT TIN AND 5 PER CENT ZINC; HOMOGENEOUS SOLUTION

Molten Metal and Damp Floors Won't Mix

By David Bell

A recent explosion in our brass foundry almost wrecked the plant, but fortunately all of the employes escaped injury. A young man from the pattern shop, who had just entered the brass foundry to deliver several models, was interested in the removal of a crucible from the brass furnace and when the explosion occurred he was thrown among some flasks. It was evident that he recog-

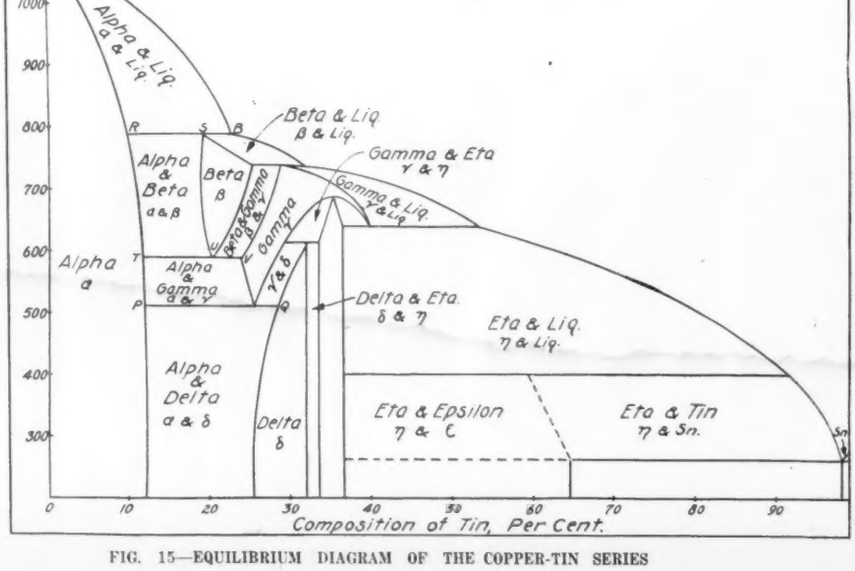


FIG. 15—EQUILIBRIUM DIAGRAM OF THE COPPER-TIN SERIES

nized instantly that some unusual stunt was taking place and he concluded immediately that it was outside for him, and he escaped by jumping through one of the windows.

The explosion was caused by the breaking of a No. 90 crucible which had been used for 28 heats and was slightly cracked on one side. The melter considered it safe to try another heat and charged it with 200 pounds of metal. Just as the crucible was being lifted from the furnace it collapsed and its contents flowed through the fuel to the ash pit floor. A terrific explosion immediately followed. The melter and his assistant were thrown to remote parts of the shop and the gratings covering the ash pit were blown out of position and a part of the bottom plate of the center furnace landed on the foundry floor. The furnace was dislodged from its bearings and the ash pit was badly wrecked.

The explosion was caused by the molten metal coming in contact with the damp ash pit floor and to this was added an explosion of dust which was shaken from the walls and roof of the building. This explosion again served notice on our employes to prevent the contact of molten metal with damp floors and merely is a repetition of what has happened so frequently in the past in other foundries. In making the necessary repairs, care was exercised to so incline the ash pit floor that all moisture would be drained off through a pipe. In this way the floor is kept dry under all conditions.

HOW AND WHY IN BRASS FOUNDING

By Charles Vickers

Eliminating Spelter Marks From Plumbers' Brass Goods

We are making plumbers' brass goods and have had considerable trouble with compression basin cocks. The difficulties consist of spelter marks located usually on the flared portion of the cock that forms the base when it is attached to the basin. This is the highest point on the mold. We also have difficulty in getting them to withstand the pressure of 80 pounds and many of them leak. We employ the following mixture: Copper, 40 pounds; brass tubing, 60 pounds; tin, 1½ pounds, and lead, 5 pounds. The molding sand is of an open grade and the metal, when poured, raises a little in the sprue. The castings are gated on the outside bend of the spout; when gated on the threaded portion that extends below the basin, the castings fail to run at the spout.

It might be well to have an analysis made of the brass tubing as it is the principal constituent of the mixture. Let us assume that it is a 60-40 brass, the alloy used for the basin cocks will be approximately as follows: Copper, 71.36 per cent; zinc, 22.53 per cent; tin, 1.40 per cent, and lead, 4.64 per cent. This should make a good mixture for this service; therefore, your troubles must be traced to some cause other than the alloy. As the heads swell, it would appear that the leakage is due to absorption of furnace gases by the metal. To prevent this, use charcoal, pieces of wood or tan bark on the metal, with a little common salt; also, add 0.25 per cent of phosphor copper a few minutes before the metal is poured. Be careful to prevent aluminum from getting into the mixture. In place of phosphorus, manganese copper can be used in the same proportion, or magnesium copper, the object being to deoxidize the metal and remove the gases dissolved therein. Careful melting is the best preventative. For the cores, open sand should be used and the cores should be well vented; the binder may be any substance that has been found to give satisfaction. If there is any dissatisfaction with the binder in use, try another and get the views of the maker as to the best way to mix it. The spelter marks are caused by slow pouring and cold metal; the metal must be cooled a little from the point where it causes the immersed skimmer to vibrate, and it must be poured with decision into the molds keeping the heads filled.

Fluxes to Use for Aluminum

What is the best flux to use in melting aluminum?

Opinions differ as to the best flux to use in melting aluminum. Some melters believe that sal-ammoniac deserves this distinction, while others will not use it. In melting aluminum no flux should be used until the metal is ready for pouring; then, if a small piece of fused zinc chloride is added and stirred into the metal, it will remove the oxides. In the absence of fused zinc chloride, common salt can be employed, but it is not as efficient as zinc chloride or sal-ammoniac.

In place of the fluxes mentioned, manganese chloride also can be used, in fact any of the chlorides act on the dross, but in varying degrees. Ammonium chloride or sal-ammoniac contains nitrogen, a gas that should be kept away from aluminum, otherwise it acts similar to the other chlorides.

Preventing the Discoloration of Freight Car Bearings

We are having considerable trouble in making freight car bearings, the difficulty being due to discolored areas of metal in the center of the shell when broken. The alloy we use consists approximately of copper, 69 per cent; tin, 7 per cent; lead, 20 per cent, and zinc, 4 per cent. We run 700-pound heats and add, just before pouring, 2 pounds of 15 per cent phosphor copper. We assume that the discoloration is caused by oxidized metal which gathers at the center, as the ends of the castings are perfect.

The discolored area in car journal and other brass castings is not necessarily due to the oxidation of the metal during the melting process. The only difference in composition between the colored areas and the normal areas is in the tin content which, upon analysis, will be found less in the case of the segregated areas. This would make the difficulty appear due to intercrystalline shrinkage, that is, the more fusible part of the alloy being last to solidify has drained away from the higher parts of the bearing to the lower parts, through the medium of spaces between the crystals. Therefore, if the metal could be so poured that the center of the bearing is fed, the colored area would disappear. Possibly the bearings could be run by a horn gate in the center of the back, casting the journals bearing up. The use of a horn gate would not cause any particular difficulties in making the mold, as such a gate is rapidly removed from the mold and can be broken easily off the casting while the latter is hot. The

pouring sprue should be made much larger than usual, which causes extra expense for melting, but this might be justified by the results. Pour the castings as cool as possible so that the metal will not stay liquid in the mold longer than absolutely necessary. Unless the phosphorous is added to specification, its content is too great as 0.25 per cent phosphor copper is ample for deoxidizing purposes. An increased amount adds to the difficulty of getting good castings.

Increase the Metal Thickness to Withstand High Pressures

We are making castings averaging from 2 to 6 pounds each in weight, but are having difficulty on account of porosity. The defects are not noticeable until the final assembling process when a test is made, with the result that many of the castings have to be discarded. Some of the castings are expected to withstand a pressure of 2100 pounds per square inch. The composition of the alloy we are using follows: Copper, 85 per cent; tin, 5 per cent; zinc, 6 per cent, and lead, 4 per cent. Can you inform us of the cause of this difficulty?

If the castings are not visibly porous, but leak when subjected to pressure, the difficulty may be due to the walls which probably are too thin. If there is any doubt on this point it would be advisable to make some test castings in which the walls have been increased in thickness. If this stops the leakage, the thickness of the walls will have to be increased, and the patterns must be changed. Also, the alloy might be changed by substituting one per cent of nickel for an equal amount of zinc. This would have the effect of closing the grain of the metal. It will be necessary to exercise great care in melting the alloy to prevent oxidation and sulphurization. To obviate this, a little salt should be mixed with the charcoal, a good way being to wet the charcoal with salt water making it merely damp, and not dripping with moisture. This will evolve fumes during the melting period, which will tend to protect the copper both from sulphur and oxygen. If there are any thick sections on the castings, feed them by the use of risers which, while they may appear ridiculous from the viewpoint of ordinary practice, nevertheless are often more necessary than is usually considered. Risers prevent the formation of internal voids between the crystals of the metal, which form a pathway through which the liquids or gases, under pressure, easily escape.

Bushing Mixture for Automobiles and Electric Motors

Kindly give us a good mixture for bushings for automobiles and electric motors; also, we would like to know the composition of the so-called Densmore mixture.

The following alloy is suitable for the bearings of automobiles and electric motors: Copper, 80 per cent; tin, 9 per cent; phosphor tin, 1 per cent, and lead, 10 per cent.

To get sound castings, it will be necessary to exercise care in melting. The copper should be melted under a covering of charcoal, and the phosphor tin added and thoroughly stirred after which allow the alloy to stand in the furnace for 5 minutes or more to give the gases a chance to escape; then add the tin and a few minutes before taking out the pot, add the lead. Stir the alloy thoroughly before pouring into the molds.

The most accurate method of obtaining the composition of the Densmore mixture, or any alloy of brass or bronze, is to obtain a sample and submit it to an experienced chemist for analysis. From a study of the analysis, it will be easy to formulate a mixture that will approximate the metal desired.

Making High Conductivity Electrical Castings

We would appreciate your advice regarding a flux for copper castings and the method of using this flux. We are making copper castings for electrodes and other electrical purposes, which must have a conductivity of 80 per cent or more.

Many founders claim to be able to get this conductivity in copper castings by the use of magnesium, and possibly for electrodes and castings that do not have to be machined, magnesium is the best deoxidizer to use. It must never be added to the copper in the form of metallic magnesium, but as an alloy of magnesium and copper containing approximately 10 per cent of magnesium and 90 per cent of copper. This alloy is easily made by melting commercially pure copper in the proper proportion and then adding the required amount of magnesium. The latter metal should be broken into short lengths, and can be tossed onto the top of the copper, then pushed down under the surface by means of a carbon rod attached to an iron rod. The magnesium will not burn or be lost if it is not allowed to lie on the surface of the copper. When all the magnesium has been added, the alloy should be quickly removed from the furnace, and should be poured into closed iron molds. If it is poured into open molds, the top of the ingot will effloresce and considerable of the metal will be lost. By using this 10 per cent magnesium copper, the required percentage of magnesium can be added with certainty to the copper. Add from 0.5 to 1 per cent of magnesium copper to the copper that is to be cast, just before it is removed from the furnace. To produce high conductivity copper castings, use only electrolytic copper, and melt it under charcoal with a flux of borax, add the minimum amount of deoxidizer that will give sound castings.

Making Monel Metal Castings

We desire to make monel metal castings and as we have had no experience with this metal we would appreciate information as to the most desirable composition for good castings, and particulars regarding the method to be followed in alloying the metal.

Monel metal contains approximately 60 per cent nickel, with the remainder copper and iron. It would naturally be an expensive alloy if it were made like nickel silver by the use of metallic nickel. In the past, however, monel metal has competed favorably with any good grade of bronze, and this has been possible because monel metal is never made up as an alloy. The metal is obtained from an ore in the Sudbury district of Canada, and the ore is simply smelted and refined to a composition approximating copper, 36 per cent; nickel, 60 per cent and iron, 4 per cent. The following is the analysis of a rolled section recently obtained: Copper, 26.70 per cent; nickel, 68 per cent; iron, 2.56 per cent and manganese, 2.55 per cent. The composition is liable to slight variations. The alloy can be made according to either of the foregoing compositions, by melting the nickel and copper together, adding the iron, and just before pouring, a little aluminum, about 0.25 per cent, to promote fluidity. The latter addition, however, cannot be used if the castings are required to withstand pressure. About 2 ounces of magnesium per 100 pounds of monel metal should be used as a deoxidizer. It is improbable, however, that the alloy can be put together to permit the castings to be sold at the price that will be expected, and which others will meet. The only way this can be done is to purchase monel metal as scrap, melt this under charcoal at a high temperature, add a deoxidizer such as magnesium, and pour into well-vented molds faced with a refractory sand.

Malleable Plant to Revert to Destined Work

Large Foundry Nearing Completion at the Beginning of the War and Subverted to Meet Shipping Needs, Now Will be Devoted to Original Purpose

COMPLETED at the time when the great emergency demanded a different product from that for which it was designed, the new Cleveland plant of the National Malleable Castings Co. rose to the occasion in the manner which was described in the April 1 issue of THE FOUNDRY. This plant has made and is making an exceptional record in the manufacture of cast steel anchor chain. Primarily, however, it was designed for the production of malleable castings for automobile service. Such of its equipment as was adaptable to the uses of chain manufacture has been completed and is in service, and work now is going forward to make the remainder of the establishment ready for its designated task. The plant is the result of years of experience interpreted in terms of the best modern foundry engineering practice.

The group of buildings embraced within the company's 32-acre enclosure includes a service department, pattern shop, main foundry with large storage and shipping bays, machine and carpenter shop and a boiler and powerhouse. These are shown in the plan reproduced in Fig. 1.

The entrance to the plant is through the service building, a 3-story structure housing the time clock lobby, time office, employment office, locker rooms, shower baths, dispensary and large club rooms. From this building, a tunnel 10 feet wide, amply lighted and well ventilated, extends beneath the entire group of buildings. This tunnel communicates through stairways with the different departments, so that workmen may pass and repass without endangering themselves or creating diversion of interest on the part of others at their work. This tunnel is viewed by the management as a most effective safety device.

The pattern building which comes next in the group is three stories high, of steel skeleton construction with brick walls, concrete and subfloors. As may be noted from Fig. 1, it is 60 x 150 feet. The first floor is devoted to plant offices. The second is given over to the pattern department of this plant alone, while the third floor is occupied by a second pattern department which makes coupler patterns for the other plants of the company located in various parts of the country.

The main foundry building is roughly 625 x 725 feet. In this spacious structure, said to be the largest single foundry unit in the world, are contained all the operating departments of the plant. The storage and shipping departments extend the full width of the building along the two ends of foundries Nos. 1, 2, 3 and 4 which are located at right angles and divided into pairs by the area which contains the core room, electric furnace and converter department, and flask storage. The structure is built according to the best modern foundry practice. Steel frame construction, with the roof carried 35 feet above the floor, ventilating windows, and liberal lighting all contribute to sanitation and comfort. The windows in this monster foundry alone total over 3½

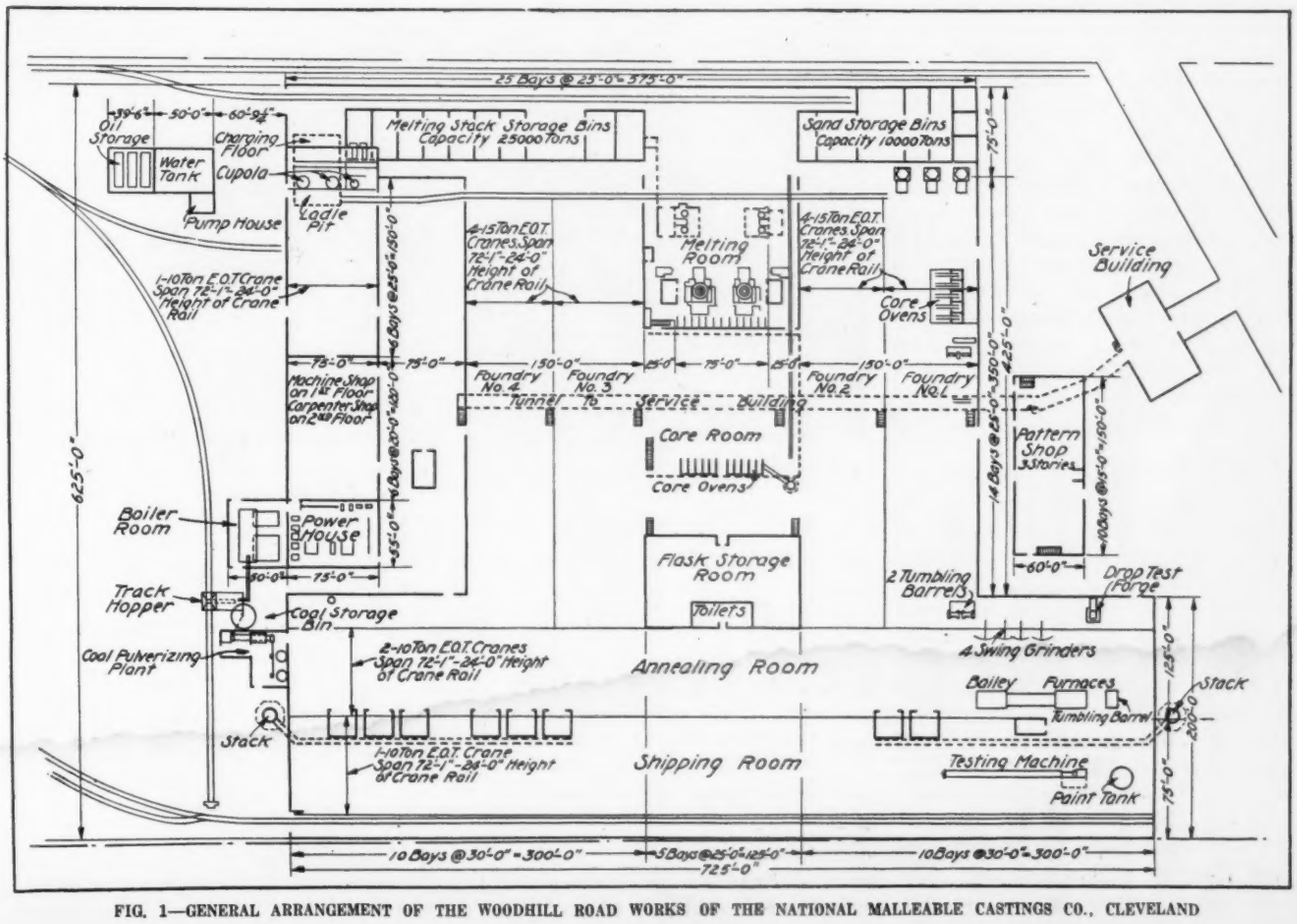


FIG. 1—GENERAL ARRANGEMENT OF THE WOODHILL ROAD WORKS OF THE NATIONAL MALLEABLE CASTINGS CO., CLEVELAND

acres of glass, while the entire floor area approaches 10 acres. The outer walls are of brick built up about 24 feet on all sides while the Aken type roof is made of concrete slabs. Overhead cranes, built by Pawling-Harnischfeger Co., Milwaukee, cover the work in all the different departments.

As was noted, the storage department extends the entire width of the bay, or will be run up on an inclined track not yet constructed. At the charging floor, tracks are provided on continuations of the lines of the two tracks along the front of the bins. The charging floor tracks have turntables and intersecting lines which will allow the cars to be run to the cupolas independently and simultaneously if desired. The trays on the cars are hinged in such a manner that

FIG. 2—AMPLE SCRAP, PIG IRON, COKE AND SAND STORAGE IS PROVIDED IN A SERIES OF BINS LOCATED ALONG THE END OF THE SEPARATE FOUNDRY FLOORS

building, along the railway siding. This storage bay is roughly 75 x 575 feet. A receiving track adjoins a series of storage bins for coke, pig iron, scrap and other melting stock at one end of the storage area and at the other end adjacent to foundry floors Nos. 1 and 2 are similar bins for sand. These nine concrete storage compartments of various sizes are 20 feet deep and provide a melting stock storage of 25,000 tons. The sand storage will accommodate 10,000 tons. The coke bins will hold 3500 tons.

A track for fuel and melting material extends along the top of the storage bins, crossing a scale, as shown in Fig. 2. This track is 8½ feet above the main floor level. At one end of the track, and 22 feet above the foundry level, is the cupola charging floor, Fig. 3. The location of the cupolas is indicated in the shop plan, Fig. 1.

Cupola charging cars of a special hopper type will be used in handling materials from the storage bins. These cars have a capacity of 2500 pounds. They will be loaded at the bins, and either elevated to the charging floor by the crane commanding the storage

bottom of the columns to the top of the stack is 65 feet. The height from tap hole to charging door is 27 feet 6 inches, giving an exceptional charging capacity and greater economy. Twelve tuyeres supplied through a 15 x 36-inch wind box are provided. Each wind box is served through two air lines. With an ordinary thickness of lining each of these cupolas would melt about 25 tons of metal per hour. With the extra heavy lining the output will be 12½ tons per hour. This capacity will provide hot metal for the entire plant, which will require about 300 tons per day. This would produce about 150 tons of finished castings per day on a basis of 50 per cent yield. It is the intention, when operating on iron for malleable casting, to run one cupola continuously for a week, and then switch to the other while relining.

The smaller cupola, shown at the right in Fig. 3, will be used to make iron for annealing pots. This is lined to 63 inches. The cupolas all were built by the Whiting Foundry Equipment Co., Harvey, Ill. All three units receive their blast from a common air

FIG. 3—TWO LARGE CUPOLAS WILL COMPLETE THE FIRST STAGE OF THE TRIPLEX PROCESS OF MAKING MALLEABLE IRON—THE SMALLER CUPOLA WILL PRODUCE GRAY IRON FOR ANNEALING POTS

an air hoist at the back of each of the cupolas may engage recesses at the back and tilt the hoppers directly through the charging doors. The cupola charging floor is 37½ x 75 feet, rigidly constructed of reinforced concrete on a steel frame and paved with wood blocks.

Two of the three cupolas are 108 inches in diameter, tapering to 72 inches, and are lined with a 26-inch wall directly above the tuyeres. This gives a diameter of 56 inches at the melting zone. The distance from the

line. Two positive pressure blowers, built by P. H. & F. M. Roots Co., Connersville, Ind., are housed in an enclosure beneath the charging floor and furnish the blast for the three furnaces.

Slag from the cupolas will be removed in 4-ton ladle cars. The iron ladles from the cupolas will be lifted by a crane and set upon a track which runs parallel with the storage-bin track, but at the foundry floor level. From this point they will be shunted along to what is termed the melting

department. Track scales will provide an accurate record of the difference or loss at this stage of preparing the metal.

In that portion of the plant designated as the melting department, two 15-ton heroult furnaces have been installed. In addition, two 2-ton, and two 6-ton side-blow converters have been provided. In the scheme for manufacturing malleable iron by the triple refining process, it is the intention to take two tons of metal from the large cupola in service, send it to the metling room, and blow it in one of the 2-ton bessemer converters. While this is in progress, additional metal will be tapped from the cupola until the cupola ladle contains about 10 tons of metal. This then will be sent to the melting room where the two tons from the converter will be added, giving the mixture the desired carbon and silicon content. This mixture then will be further refined in one of the electric furnaces. The result is intended to overcome conditions resulting from too high carbon, silicon and manganese.

This melting room equipment makes plain the facility with which the plant was directed to the purposes of steel-chain manufacture. In this case, the cupolas and converters, which have not yet been placed in operation were not needed. The two heroult furnaces provided the necessary capacity for the chain work, as they melt four or five charges of cold scrap per day.

The two electric furnaces are identical. The outer shell in each case is 13 feet, 6 inches in diameter. Three 12-inch electrodes are used. Thirty heavy copper lead cables deliver current from the 3000-kilovolt-ampere transformer which is housed at the back of each furnace. Special hollow tube conductors are used in place of the usual bus-bar arrangement. These tubes which effect a two-thirds saving in copper over the usual type of conductors are supplied with cooling water which maintains a low temperature. The electrodes are automatically fed down as the charge is melted. As may be noted from Fig. 5, the furnace is tilted on an axis located at the front. The tilting control is electrically-driven through gears balanced by a counter-weight at the rear.

Hot metal from the melting department may be shunted on ladle cars in either direction to a point where it can be handled by the cranes commanding each of the different foundry floors where it is finally poured.

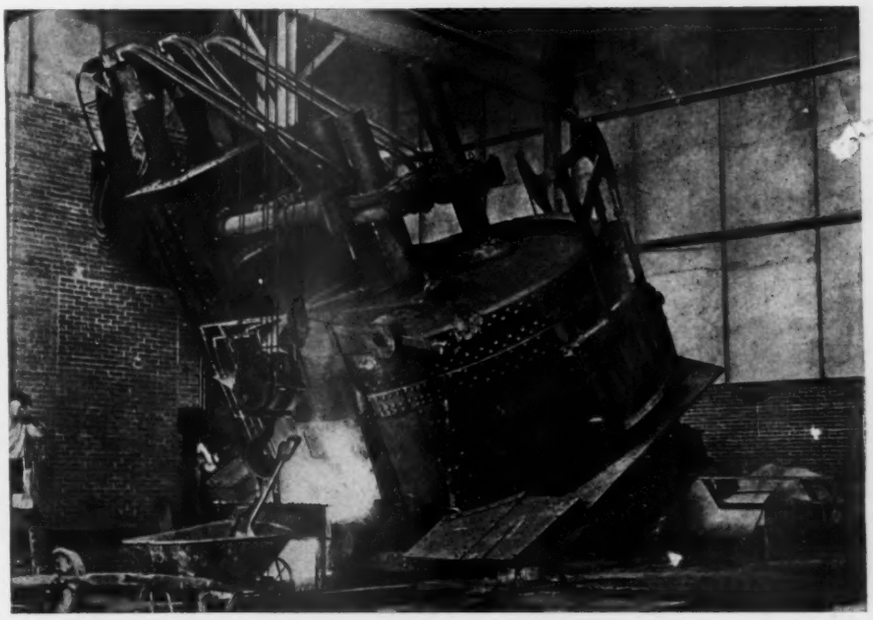


FIG. 5—ONE OF THE TWO 15-TON ELECTRIC FURNACES IS SHOWN TILTED FOR POURING—THE ARRANGEMENT OF WATER-COOLING PIPES TO THE CONDUCTORS MAY BE NOTED LEADING FROM THE CABLES TO THE ELECTRODE HOLDERS

FIG. 4—TWO BATTERIES OF FIVE OVENS EACH GIVE A LARGE CAPACITY WHICH IS AMPLE TO TAKE CARE OF THE REQUIREMENTS OF THE FOUR FOUNDRY FLOORS—ELECTRIC BATTERY TRUCKS HANDLE THE CORE RACKS INTO AND OUT OF THE OVENS

In the same section of the building with the melting department, the original scheme contemplated a core room, and at the far side of this core room, two batteries of five ovens each were built. These fitted admirably into the chain manufacture for baking the dry sand molds used. The core ovens are 5 x 15 x 7 feet, and each division will accommodate two racks of cores. The racks are handled by elevating platform trucks, as shown in Fig. 4.

Communicating with the core room and almost in the center of the building is a 4-story structure of steel and concrete with stairways and elevators. This will be used for storing molding machines, flasks, boards and other floundry floor supplies. The general plant store room occupies the first story of this inner building.

At present only foundries Nos. 1 and 2 are in use, and these are devoted to molding and casting anchor chain. Eventually, along the dividing walls, between the foundry units, stalls 10 feet wide will be built. These will provide a series of molding floor units each 10 x 35 feet. Each molding floor will provide space for 70 molders.

Hot metal from the melting room will be delivered by 7-ton ladles. From these it will be poured into bull ladles for the casting operations.

At the eastern part of the main building and extending across the ends of the different foundries, similarly to the storage department, is the annealing department. This occupies a space 75 x 725 feet, and forms the last step in the sequence of the many different successive operations through the plant.

At present only two batteries of the eight annealing ovens have been constructed at one end of the wing devoted to this purpose. The space is ample for 24 to take care of all the work which the foundries can produce. Each of the present ovens has a capacity of 40 tons of automobile castings contained in 104 stacks of pots placed four high. The ovens are 20 feet wide and 25 feet long. They are insulated by 4½ inches of special silica brick. Powdered coal supplied by the company's plant will be used for fuel. This will be mixed with air and blown through four burners located well up on the wall of the furnace in such a manner that the flames will meet and cross, returning and circulating at a lower level.

Adjacent to the annealing room and in the same bay is the shipping department, 100 x 725 feet. Railway track space for from 18 to 20 cars is provided to ship the malleable castings which started in the opposite side of the foundry as raw material, and finished their progress in the annealing ovens. The floors of the annealing and shipping departments are paved with wood blocks and electric trucks will be used to charge and discharge the ovens.

The boiler and powerhouse adjoins the main foundry, but is a separate brick and steel structure. The boiler-room equipment includes three 350-horsepower Connelly water tube boilers with Murphy stokers. A steam blower ash removal system discharges the ash from the pits beneath the boilers into a concrete tank outside the building, in the manner familiar in marine boiler installations. From this point a yard crane loads the ashes in cars for removal. A complete coal crushing plant furnishes fuel for the boilers and for the malleable annealing furnaces. The boiler plant is used for heating purposes only. The entire plant including the mammoth main foundry building is heated by the forced circulation of hot water through pipes placed along all the walls. The magnitude of this heating system will be appreciated from the fact that over 50 miles of 1½-inch pipe were required in the main foundry building alone for radiation. In the powerhouse are heaters, pumps, etc., for the heating system, and also the electrical equipment required.

Electric power for the plant including that used in the furnaces is obtained from the Cleveland Electric Illuminating Co. All wires within the plant are contained in conduits radiating underground from the power house. All subdivisions of power and light throughout the plant are metered to provide an accurate distribution of cost between departments. Six miles of fiber conduit are in use underground and 12 miles of metal conduit are required in the leads above ground.

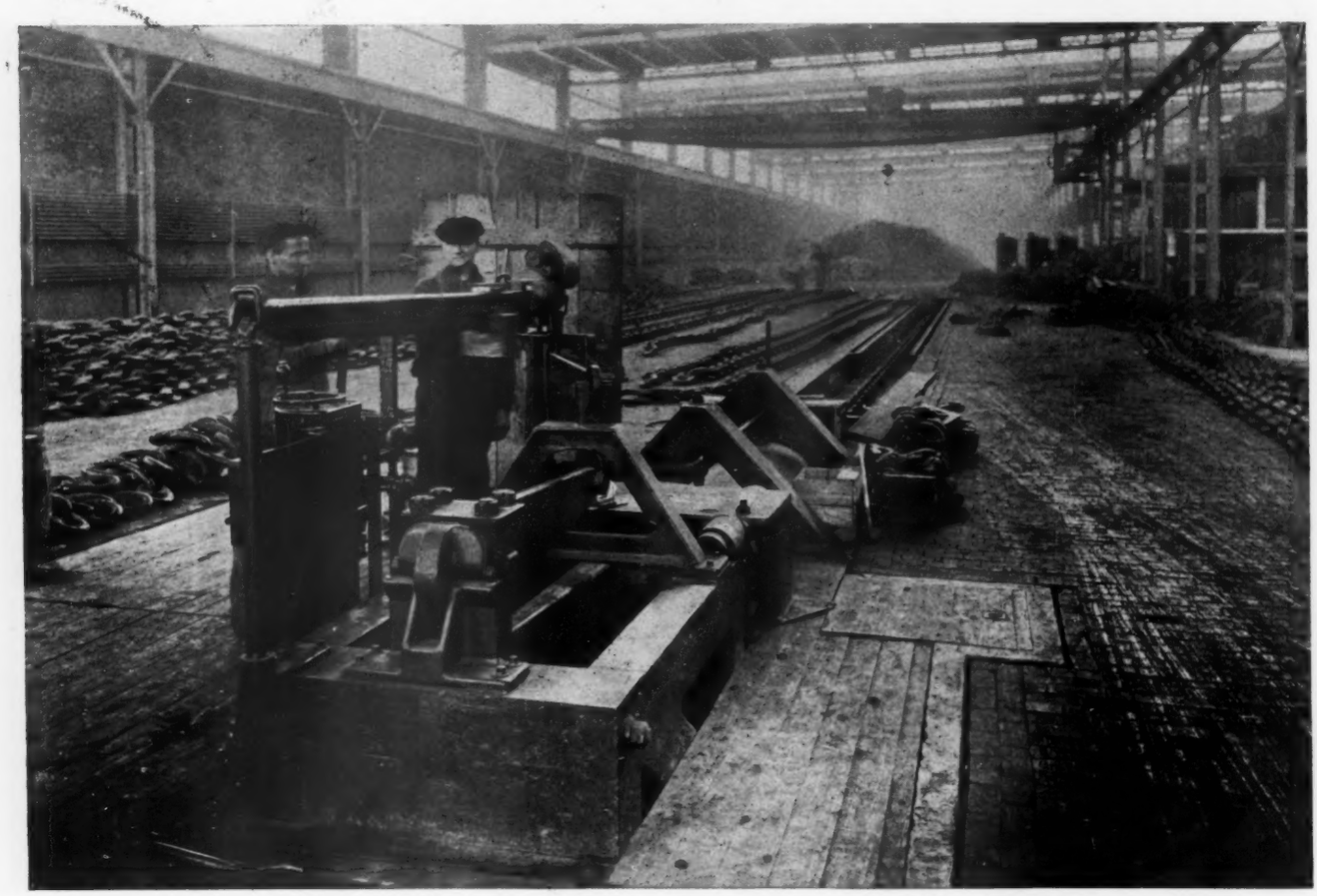


FIG. 6—THIS LARGE FLOOR AT PRESENT DEVOTED TO TESTING AND INSPECTING CHAIN WILL BE THE SHIPPING BAY, AND WILL ACCOMMODATE 18 TO 20 CARS FOR LOADING UNDER PROTECTION OF THE ROOF OF THE MAIN BUILDING

American Blower Co. Will Build

The Charles C. Kawin Co., foundry engineers, Chicago, has been retained as consulting foundry engineers by the American Blower Co., Detroit, and will work in conjunction with the firm of Albert Kahn, architects, of the same city, for the design and erection of the foundry to be built by the American Blower Co. The plant will be erected on the outskirts of Detroit. The main foundry building will be 200 x 400 feet and, in addition, another building will be erected several stories high, the lower floors of which will be devoted to cleaning and rough casting storage, with the pattern shop and pattern storage on the upper floors.

Morris L. Cooke, H. K. Hathaway, Boyd Fisher, Keppele Hall and John H. Williams have opened an office of consulting engineers in management in the Finance building, Philadelphia.

Elementary Discussion of Foundry Metallurgy

Factors Influencing the Proper Proportion of Pig Iron and Other Constituents That Enter the Melt Are Studied from a Practical View Point

By W W Cox

THE two principal kinds of pig iron available for the foundrymen of the western Kansas district are northern and southern. Charcoal iron also is used to some extent. The adaptability of a brand of pig iron for a certain class of castings usually will depend upon the phosphorus content of the iron more than upon any other element, as this is fixed by the ore mixture charged into the blast furnace and is not reduced by the smelting of the ore, the same as the other metalloids.

The practical foundryman's theory that a mixture of pig irons of a certain analysis with scrap, when melted and thoroughly mixed, produces better castings than a mixture of one grade of pig iron and scrap has been disputed, but has been verified by practical operation.

Since the chief characteristic of northern pig iron is its low phosphorus content and that of southern iron, high phosphorus, it would seem that a mixture of both irons would be desirable in the proper proportions as determined by the phosphorus content of the mixture. Generally speaking, the percentage of silicon in the pig iron should be governed by the thickness of section of the castings to be made. For ordinary foundry work, the percentage of manganese in the pig irons should average 0.60 per cent, or more, depending upon the sulphur content of the scrap with which the pig irons are to be mixed. The sulphur should be low in both pig iron and coke.

It is impossible to give any formula of the relative importance of the different metalloids, other than sulphur, in pig iron. Any element that is either abnormally high or low, is the most important element in the mixture.

The proper percentage of pig iron and scrap in the mixture is governed largely by the price received for the castings and the amount of machine work to which the castings are to be subjected.

With normally good coke, the sulphur in the castings is largely derived from the scrap in the mixture. The relative price of pig iron and scrap is the factor determining the percentage of scrap to be used in the mixture.

It has been our experience that a certain proportion of bought scrap of good quality is a distinct advantage in the mixture and is not detrimental to the quality of the castings. This proportion of scrap, however, should be governed largely by the sulphur content of the castings to be produced. The stove foundries of this section, during the past year, have had to use an unusually large quantity of bought scrap in their mixtures, with the result that the sulphur in the stove plate made was abnormally high.

However, we have known of several instances where the sulphur ran as high as 0.13 per cent in stove plate for a long period and no particular loss was noted either in misrun work or in breakage. That no trouble was caused by this large content of sulphur in the stove plate, was due to the simple expedient of having four times as much manganese as sulphur and 25 times as much silicon as sulphur, in the castings. Sulphur increases the heat-resisting property of hard or white iron and decreases the heat-resisting property of gray iron. It is not claimed, however, that high sulphur is of any particular advantage in stove plate. It is merely a practical proof that sulphur can be isolated and rendered less harmful by being properly combined.

Proportioning the Charges

It is an unfortunate fact that a mixture of the proper proportions and of the best materials, can be ruined in the cupola. The proper proportioning of the sizes of the different pieces of scrap and pig and the proper placing of them in the charges is a big factor in the uniform melting of a mixture. The adjustment of the height of the coke bed and the maintenance of the height of the bed during the heat to conform with the volume and intensity of the blast, is of the greatest importance. To charge and melt a mixture so that the analysis of each tap will be practically the same, requires a combination of experience, skill and judgment.

In the interpretation of the results from an analysis of gray iron, the total carbon is relatively of not much importance. It is true that pig iron usually contains more total carbon than scrap, or in other words, there is generally a loss of carbon in melting, so that a certain percentage of pig metal in a pig and scrap mixture is fairly well represented by the total carbon of the castings produced. On the other hand, coke is largely carbon and the more coke used in the melting of a mixture, the higher is liable to be the total carbon of the castings. As coke contains sulphur also, the excessive use of this fuel will cause the castings to be higher in sulphur than normally would be the case.

An illustration of this was found in the case of a foundry trying to melt iron with a coke ratio of 1 to 14, including the bed. The result was disastrous. As the iron was melted at and not above the tuyeres, the blast had no chance to become preheated before striking the heated iron and the result was that the iron was burned so badly that fully 30 per cent of the entire heat was converted to a reduced form of oxide of iron or slag, that floated out of the tap hole on top of the iron. The slag could not be distinguished from the molten iron, but it was apparent that something was wrong when the wind box filled with slag. The bottom had to be dropped and then the oxide of iron splashed and flowed all over the shop. It was interesting to note, however, that the total carbon of the castings that actually were made was 2.80 per cent; of this, 1.20 per cent was combined carbon.

Another illustration was in the case of a large foundry using a 40 per cent pig mixture and a melting ratio of 1 to 6. The total carbon of the castings produced averaged about 3.50 per cent. Only under unusual conditions of mixing and melting is the total carbon in gray iron of any value and then only as a verification that something abnormal has happened to the iron.

The total carbon in semisteel can-

From a paper presented before the Western Foundrymen's association, Kansas City, Mo.

not be controlled readily by the foundryman. As semi-steel castings should have 6 to 8 times as much manganese as sulphur in the castings, and as manganese tends to cause the mixture to absorb more carbon from the coke, one would be inclined to think that the semi-steel produced would be high in total carbon. It should be remembered, however, that the steel in the semi-steel mixture contains very little carbon and dilutes or lowers the total carbon of the mixture. For this reason it is well to use some additional coke in the melting of semi-steel.

In the manufacture of hard iron for malleable or other purposes, the carbon should be in the combined form. The amount of total carbon is of great importance, although it cannot be controlled so easily when melting in the cupola as when melting in the air furnace.

In the gray iron foundry the combined carbon may be said to be fairly representative of every operation that the iron has been through, including mixing, melting and pouring. By mixing is meant the correct assembling of the proper number of pounds of silicon, phosphorus, sulphur and manganese in each charge, and the proper distribution of the pieces of iron containing these metalloids. The melting of the charge, either high or low in the melting zone, affects the combined carbon of the castings. The size of the mold into which the hot iron is poured, in other words the rate of cooling, has much to do with the resulting combined carbon of the castings.

Large Order for Electric Brass Furnaces Placed

At the annual meeting of the American Metallurgical Corp., Philadelphia, officers were elected as follows: S. R. Vanderbeck, president; F. J. Ryan, vice president, treasurer and general manager, and S. H. Ourbacker, secretary. Changes in the operating personnel were made as follows: F. H. Shaw, formerly in charge of purchases and accounting, was appointed manager of the Conshohocken, Pa., plant of the company, and James L. Hawley, formerly auditor of the Samman Coal & Coke Co., Philadelphia, succeeds Mr. Shaw. L. W. Bechtel was appointed superintendent of construction and H. A. Horner, formerly with the Midvale Steel & Ordnance Corp., has been placed in charge of the metallurgical department. H. A. Morlock, formerly in charge of the heat-treating equipment at the Watertown arsenal, is in charge of equipment operation.

An order recently was received from the Ajax Metal Co., Philadelphia, for the installation of 15 Ajax-Wyatt electric brass furnaces and one for an addition to their aircraft plant, Shelby, O. Additional land also has been secured at Conshohocken, Pa., for the erection of a practical operating furnace laboratory where experimental heats in electric furnaces up to 700 pounds can be taken off under practical working conditions.

Will Construct New Foundry

The Connersville Blower Co., Connersville, Ind., manufacturer of rotary positive-pressure blowers, gas exhausters and pumps, contemplates the erection of a gray iron foundry in the near future. This plant will replace the gray iron shop which now produces castings for the company's requirements. The building will be of structural steel construction with brick side walls, 300 feet long and 130 feet wide, with a gable roof over the charging floor. The main portion of the foundry is to be served by two 2-ton, 50-foot electric cranes running the full length of the shop. The crane runway will be 25 feet above the floor level. Each of the side bays will be served by a 5-ton 36-foot electric traveling crane. The one serving the bay opposite the charging floor will operate the full length of the foundry, while on the cupola side the cranes will operate only one-half the length of this structure. The height from the floor to the crane rail in the bays will be 16 feet. Two 72-inch cupolas will be installed in the center of one bay and the charging floor will be 39 x 53 feet. It will be elevated 20 feet from the ground and 10 feet above this floor will be located the coke storage, 20 x 53 feet.

Lubricating the Cylinders of Air Compressors

(*Concluded from page* 214)

feed to the air cylinders of compressors, cannot be stated in exact terms due to the varying viscosity of different oils, the heat of compression and the size of cylinder. It may be stated in general, however, that after the cylndiers have acquired smooth and polished surfaces, the quantity should be reduced to the lowest limit to avoid the possibility of the accumulation of carbon and sooty deposits within the system.

The basis of quantity given in Table III is recommended, subject to modifications for these cylinders or equivalent sizes, operating under normal conditions.

It will be understood that the results in the last column of Table III are based upon the assumption that under average conditions of temperature and usual range of oil viscosities, a pint of oil will contain about 16,000 drops. These figures are offered merely as an approximate guide and that every individual must exercise judgement in modifying them to any particular set of working conditions.

A leading authority on compressor engineering states that the best way to determine the proper amount of lubrication is to take out the valves from time to time and examine the cylinder. If parts feel dry, the lubricators should be adjusted to feed more oil, if oil lies in the cylinder and its parts show excessive oil, the quantity fed by the lubricators should be reduced.

The proper quantity of oil to be fed to steam cylinders is much greater than to air cylinders due to the constant washing away of the oil by the steam. Approximately four times as much oil will be needed in the steam cylinders as in those for air, subject, of course to variable conditions. Depending on its viscosity, a pint of steam cylinder oil will furnish from 5000 to 8000 drops, and taking an average of about 6500 drops, and four times as much oil as air cylinders of same size, and working at same piston speeds, as given in Table III, the recommended amounts to feed the steam cylinders may be approximated.

Establishes New Branches

The Chicago Pneumatic Tool Co., Chicago, has established a branch office and warehouse in the Richard building, Tulsa, Okla., and at El Dorado, Kans., to supply the demands for its products in the Oklahoma and Kansas fields. The Boston office of this company has been removed to 182 High street. F. S. Eggleston is New England district manager of sales. The Detroit office of this company also has been removed from 236 Hancock avenue to 502 Farwell building.

Installs New Tinning Equipment

The New Standard Hardware Works, Inc., Mount Joy, Pa., recently has closed a contract for the installation of hot tinning equipment in the plant of the Sturges & Burns Co., Chicago. Installations also recently have been made by the Buhl Stamping Co., Detroit, and at the plant of the National Enameling & Stamping Co., Milwaukee.

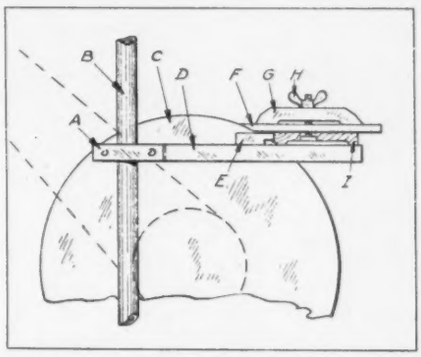
The twenty-second edition of the *Manual for Engineers,* published by the University of Tennessee, Knoxville, Tenn., contains many valuable tables arranged in consistent form for the engineering profession. The book, is vest pocket size and has 238 pages.

Pointers for the Patternmaker and Molder

Device for Grinding Plane Irons—Cutting Gages Aid Accuracy—A Simple Mold Vibrator —Design for Simple Flask Pin-Casting Plaster of Paris—Patternmaking for Steel Casting

I HAVE heard men say, who are constant users of edge tools, that the grinding of such a tool gives them little trouble. I cannot say the same as the contrary is true with me. The grinding of a plane iron, to the correct angle, flat on the angle face and straight across the cutting edge, gives me considerable trouble.

The device described herewith, was designed by a cabinetmaker whose early training and experience in tool grinding was along practical lines. In connection with his regular duties as an apprentice he was expected to keep the shop grindstone in first-class condition. Conditions permitting, he was given the job of grinding many of the edge tools for the other workmen in the shop. In this way he learned a great deal about the art of grinding edge tools. However, he said that it took months of practice to enable him to grind a plane iron correctly to a true edge. As a means to this end, he rigged up a temporary wood fixture to which the plane iron is fastened while being



FIXTURE FOR RAPIDLY GRINDING PLANE IRONS STRAIGHT AND TRUE

ground. I call this a temporary fixture because, being made of wood, it is affected by the water from the stone. Made of metal it would be permanent.

The grindstone is placed close to a 3-inch iron building column. To this column is fastened the wooden table *D*. It will be noted that there is only one fixed guide, *E*. Loosely mounted on the table *D* is the wooden frame *I*. The plane iron, *F*, is fastened securely to the frame *I*, by the wooden clamp *G* and the nut *H*. With the table *D*, and the sliding frame *I*, placed in the correct relative position to the stone, the plane iron will be ground to the correct angle. By means of the sliding frame *I*, the plane iron is passed back and forth across the stone thus grinding it straight and to the angle desired.

The reason for the use of one fixed guide only is to permit the frame *I*, with the iron fastened to it, to be readily lifted away from the stone for examination during the grinding operation. It is necessary that the device be constructed strong and rigid, otherwise the grinding cannot be done in a satisfactory manner.

M. E. DUGGAN.

Cutting Gages Aid in Securing Accuracy

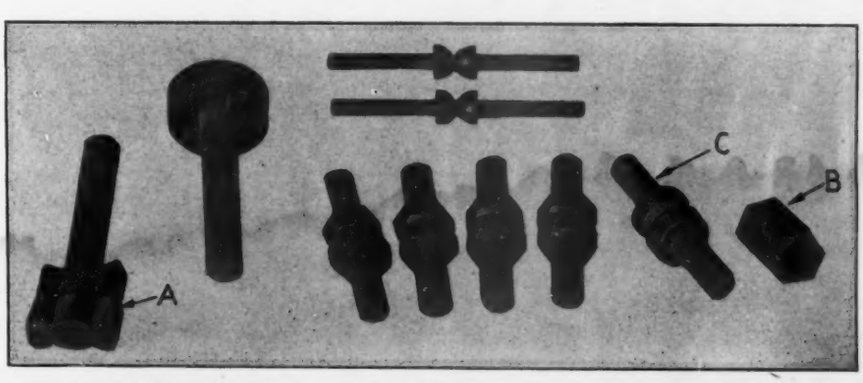
By J L Gard

MAKING small duplicate patterns to meet limitations in shape and dimension requires accuracy. Consider the small valves and bolt patterns in the accompanying illustration. In both of these cases, close tolerances required that the duplications should be perfect.

To make the valve pattern shown, the large recessed head was turned on a lathe in the usual manner. The stem then was turned with a mushroom head having an outside diameter equal to that of the recess in the valve head. The portion between the two lugs at the top of the stem then was cut away by the use of a template or cutting gage, shown at *A*. This gage was placed against the end of the larger disk head and the space between the lugs was cut out with a chisel. The template was made with the proper draft which was transferred to the lugs. The valve stem had a ¼-inch pin in the center which fitted into a center hole in the template. This assured the exact duplication of the lugs and the same draft. The parts, when completed were smoothed, finished and glued together to form the complete pattern shown.

In the patterns for the small brass bolts shown, it was essential that the hexagon head should be accurate. To secure this accuracy a special gage, shown at *B*, in the accompanying illustration, was made. This gage was made in the form of a sleeve which fitted the shaft of the bolt. The hexagon outer surface then was cut with the greatest care to insure accuracy. The bolts were turned with the larger portion to form two heads at the center, shown at *C*. The sleeve gage then was slipped over the shaft of the bolt and the hexagon head was formed. Both speed and precision were secured by this method.

The greatest care must be used in preparing the cutting gages which are used, as will be readily appreciated. The sleeve gage described, is applicable to patterns which have the similar arrangement of shaft and head. Where similar conditions of a number of duplicate pieces which must be perfect replicas are encountered, this method is useful.

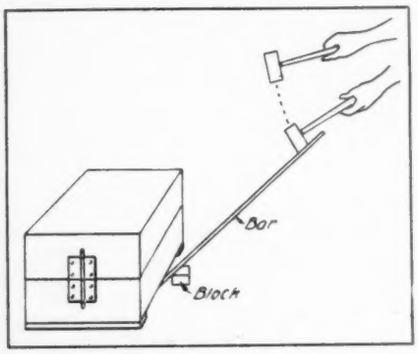


THE CUTTING GAGES SHOWN AT *A* AND *B* AIDED IN SECURING THE PERFECT DUPLICATION AND PRECISION IN MAKING THE SMALL PATTERNS FOR VALVES AND BRASS BOLTS

A Simple Mold Vibrator

By William Broadbent

The vibrator shown in the accompanying illustration is designed to prevent *drop-outs* and loosening of parts of the mold through rapping the cope. The principle is simple. It is based on the fact that a disturbance to the foundation of any structure is transferred through the whole fabric, where



AN IMPROVISED MOLD VIBRATOR

elasticity is absent. The jar to the foundation in this case is imparted through the bar or lever shown. The short end of the bar is inserted beneath the bottom-board of the mold, with a small wedge or block of wood holding it firmly against the bottom-board. A hammer is pressed against the long end of the lever and lightly rapped with a second hammer. This imparts a jar which is transferred to the entire mold, without resulting in shifting the flask on the bottom-board. Heavier molds may be vibrated by using a longer bar. The method insures a clean lift without disturbing the upper half of the mold.

Novel Design for a Simple Flask Pin and Socket

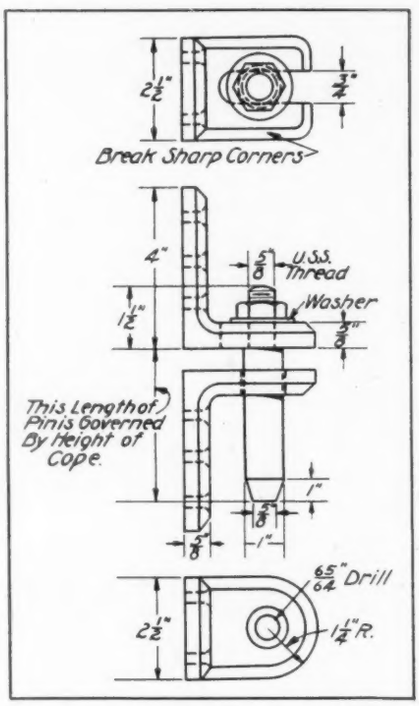
By Henry Wedde

The accompanying illustration shows a novel flask pin and socket which was designed to prevent a shift between the drag and cope flasks of a mold. The common system employing flask pins made from pieces of 2 x 4-inch blocks nailed in place to guide the cope in closing, sometimes results in serious inaccuracies. The type of pin here shown may be made easily by any foundryman.

The settings for the pin are made as indicated in the illustration. The brackets are screwed squarely to the flask. The bracket with the socket is fastened to the drag and the slotted piece is screwed to the cope. Both brackets are placed before the pin is set. The cope and drag halves next are placed together so that the edges match. The pin of the desired length is then put in place, the nut and washer attached and tightened. When a mold is made in flasks equipped with these attachments, no anxiety need be felt that a shifted casting will result.

Casting Plaster of Paris

In casting plaster of paris it will be found that the cast is considerably stronger when the plaster has been mixed with warm, rather than cold water. Plaster mixes most readily with water, and is most soluble when



FLASK PIN AND SOCKET SECURE AGAINST FLASK SHIFT

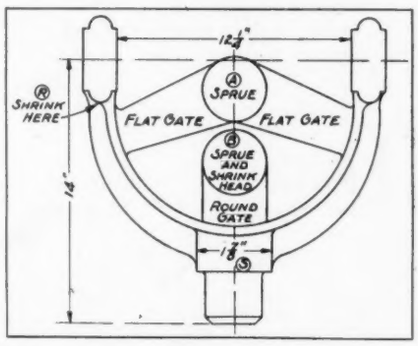
the water is at a temperature of 170 degrees Fahr.; also, the plaster sets stronger when it is made with a minimum of water. A quick-setting plaster can be made by mixing ground dust from an old plaster object as each crystal of old plaster forms a nucleus around which the new crystals can form. A solution of dextrin has a weakening effect on plaster; a small amount of dextrin will reduce the strength of plaster 50 per cent and gum arabic has a similar effect. Water glass also gives unfavorable results. When colored plaster is desired, the colors should be mixed dry.

Frederic B. Stevens, Detroit, recently was awarded a contract by the board of education of the city of Detroit for the complete equipment of a gray iron foundry in the Cass Technical high school. The installation will include a Newten cupola, positive-pressure blower, pneumatic sand sifter, tumbling barrels, melting furnace, etc.

Pattern Making for Steel Casting

By M. E. Duggan

In the last quarter of a century the steel casting industry has grown tremendously and many problems in patternmaking had to be solved, since there are many details in practice that never appear on the drawings. The pattern for the bracket, shown in the accompanying illustration, is easily made by the patternmaker and involves no trouble for the molder providing the castings are produced in gray iron or brass. However, the problem is entirely different if the casting is to be made in steel. A pair of metal patterns for this job was made gated as shown at *A*. The casting, however, proved unsatisfactory, shrink holes having developed in the corners *R* and on the hub *S*, and gated as shown at *A*, the shrinkhead was without value. At the suggestion of the foreman of the steel casting department, the location and shape of the shrinkhead and sprue were altered as indicated at *B*. By this method of gating the filling and feeding of the mold was satisfactorily accomplished and of the 300 castings made from the patterns gated in this manner, only nine proved unsound. The shrinkhead in this case equalled the weight of the cast-



HOW A PATTERN FOR A STEEL CASTING WAS ALTERED TO OVERCOME SHRINKAGE DIFFICULTIES

ing. It is evident from the foregoing that experimenting in steel is an expensive proposition. I would never attempt to make a pattern, particularly of the metal type, without first consulting the foundry foreman, particularly when a large number of castings is to be produced from the same pattern. Frequently, castings have been made of gray iron or brass originally intended to be cast in steel, for the reason that the design did not adapt itself to steel.

The Syracuse Smelting Works, Brooklyn, N. Y., hereafter will conduct the sale of its products under the name of the parent company, the United American Metals Corp.

EPICYCLOIDAL GEAR TEETH

By Walter M. Hippler

(*Continued from Data Sheet No.* 280)

A=0.3 x pitch=distance between the pitch and addendum circles.

B=0.375 x pitch=distance between pitch and root circles.

C=0.466 x pitch=thickness of gear tooth.

D=distance from pitch circle to line of flank centers.

E=distance from pitch circle to radius base line.

F=face radius of gear tooth.

G=flank radius of gear tooth.

Table VII

Values for Layout of 25-29-Tooth Gear

Pitch	A	B	C	D	E	F	G
½	5/32	1/16	15/64	3/64	3/32	3/16	31/64
¾	7/32	3/32	11/32	7/32	3/32	1/16	31/64
1	1/16	3/16	15/32	1/16	3/64	¾	1 1/16
1⅛	11/32	21/64	17/32	21/64	1/16	37/64	1 11/32
1¼	3/16	15/32	21/64	21/64	1/16	19/32	1 5/8
1⅜	13/32	23/64	21/64	13/32	1/16	1 1/64	1 23/32
1½	1/16	1/16	1/16	1/16	3/64	1 1/64	1 21/32
1⅝	½	5/16	¾	15/64	3/64	1 11/64	2 1/64
1¾	17/32	21/64	13/32	½	3/32	1 11/64	2 3/32
1⅞	1/16	11/64	7/16	25/64	3/32	1 25/64	2 1/16
2	19/32	¾	15/32	21/64	3/64	1 31/64	2 29/32
2¼	11/32	27/32	1 3/64	31/64	3/64	1 33/64	2 15/16
2½	¾	15/16	1 15/32	33/64	1/8	1 7/8	3 1/4
2¾	29/64	1 15/32	1 15/32	61/64	1/64	2 3/32	3 1/16
3	33/64	1 1/8	1 19/32	7/8	1/32	2 5/32	3 29/32
3¼	31/64	1 7/32	1 23/32	15/16	1/64	2 13/32	4 3/16
3½	1 3/64	1 1/16	1 5/16	1 1/64	1/64	2 29/32	4 1/16
4	1 11/64	1½	1 25/32	1 5/32	1/32	2 31/64	5 13/32

Table VIII

Values for Layout of 30-36-Tooth Gear

Pitch	A	B	C	D	E	F	G
½	5/32	1/16	15/64	3/64	3/32	3/16	33/64
¾	7/32	3/32	11/32	7/32	3/32	1/16	33/64
1	1/16	3/16	15/32	15/64	1/16	33/64	1 1/16
1⅛	11/32	21/64	17/32	1/4	1/64	37/64	1 13/32
1¼	3/16	15/32	21/64	1/8	1/64	19/32	1 5/8
1⅜	13/32	23/64	21/64	1/16	1/32	1 1/64	1 23/32
1½	1/16	1/16	1/16	1/32	1/32	1 1/64	1 21/32
1⅝	½	5/16	¾	3/16	1/32	1 1/8	1 31/32
1¾	17/32	21/64	13/32	1/8	1/64	1 11/32	2 1/64
1⅞	1/16	11/64	7/16	1/16	1/64	1 37/64	2 1/16
2	19/32	¾	15/32	1/8	1/32	1 13/32	2 29/32
2¼	11/32	27/32	1 3/64	1/16	1/32	1 17/32	2 15/16
2½	¾	15/16	1 15/32	1/16	1/32	1 21/32	3 1/4
2¾	29/64	1 15/32	1 15/32	1/32	1/64	1 25/32	3 1/16
3	33/64	1 1/8	1 19/32	1/32	1/64	1 29/32	3 29/32
3¼	31/64	1 7/32	1 23/32	1/32	1/64	2 1/32	4 3/16
3½	1 3/64	1 1/16	1 5/16	1/32	1/64	2 5/32	4 13/32
4	1 11/64	1½	1 25/32	1/32	1/64	2 9/32	4 7/16

(*Concluded on Data Sheet No.* 282)

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note book form.

EPICYCLOIDAL GEAR TEETH

By Walter M. Hippler

(*Concluded from Data Sheet No.* 281)

Table IX

Values for Layout of 37-38-Tooth Gear

Pitch	A	B	C	D	E	F	G
½	5/32	1/16	15/64	3/64	1/32	33/64	1/16
¾	7/32	3/32	11/32	7/32	1/32	37/64	1/16
1	1/16	3/16	15/32	13/64	1/64	41/64	1 1/16
1⅛	11/32	21/64	17/32	7/32	1/64	21/32	1 1/4
1¼	3/16	15/32	21/64	1/4	1/32	1	1 1/16
1⅜	13/32	23/64	21/64	3/32	1/32	1 1/32	1 13/16
1½	7/16	1/16	1/16	13/64	3/64	1 7/64	1 15/16
1⅝	½	5/16	¾	21/64	3/64	1 11/64	2 1/16
1¾	17/32	21/64	13/32	1/8	1/64	1 19/32	2 3/16
1⅞	1/16	11/64	7/16	3/16	1/64	1 25/64	2 5/16
2	19/32	¾	15/32	13/64	1/64	1 29/32	2 1/4
2¼	11/32	27/32	1 3/64	31/64	1/64	2 1/32	2 13/16
2½	¾	15/16	1 15/32	½	1/64	2 5/32	2 15/16
2¾	29/64	1 15/32	1 15/32	33/64	1/64	2 9/32	3 7/16
3	33/64	1 1/8	1 19/32	17/32	1/64	2 13/32	3 15/16
3¼	31/64	1 7/32	1 23/32	35/64	1/64	2 17/32	4 7/16
3½	1 3/64	1 1/16	1 5/16	9/16	1/64	2 21/32	4 15/16
4	1 11/64	1½	1 25/32	37/64	1/64	2 25/32	5 7/16

Table X

Values for Layout of 49-72-Tooth Gear

Pitch	A	B	C	D	E	F	G
½	5/32	1/16	15/64	3/64	1/64	17/32	1/16
¾	7/32	3/32	11/32	1/8	1/64	5/8	1/16
1	1/16	3/16	15/32	11/64	1/64	21/32	1 1/16
1⅛	11/32	21/64	17/32	1/16	1/64	11/16	1 1/16
1¼	3/16	15/32	21/64	3/32	1/64	1 3/32	1 1/16
1⅜	13/32	23/64	21/64	1/16	1/64	1 1/16	1 1/16
1½	7/16	1/16	1/16	1/16	1/64	1 1/8	1 1/16
1⅝	½	5/16	¾	11/64	1/64	1 13/64	1 1/16
1¾	17/32	21/64	13/32	1/16	1/64	1 17/64	1 1/16
1⅞	1/16	11/64	7/16	1/16	1/64	1 21/64	1 1/16
2	19/32	¾	15/32	1/16	1/64	1 25/64	1 1/16
2¼	11/32	27/32	1 3/64	1/16	1/64	1 33/64	1 1/16
2½	¾	15/16	1 15/32	1/16	1/64	1 41/64	1 1/16
2¾	29/64	1 15/32	1 15/32	1/16	1/64	1 49/64	1 1/16
3	33/64	1 1/8	1 19/32	1/16	1/64	1 57/64	1 1/16
3¼	31/64	1 7/32	1 23/32	1/16	1/64	2 1/64	1 1/16
3½	1 3/64	1 1/16	1 5/16	1/16	1/64	2 5/64	1 1/16
4	1 11/64	1½	1 25/32	1/16	1/64	2 13/64	1 1/16

Table XI

Values for Layout of 73-144-Tooth Gear

Pitch	A	B	C	D	E	F	G
½	5/32	1/16	15/64	3/64	3/64	33/64	½
¾	7/32	3/32	11/32	7/64	1/16	33/64	¾
1	1/16	3/16	15/32	3/64	3/32	33/64	1
1⅛	11/32	21/64	17/32	3/32	3/64	1 3/64	1 1/8
1¼	3/16	15/32	21/64	1/16	3/64	1 3/64	1 1/4
1⅜	13/32	23/64	21/64	1/16	1/32	1 1/32	1 3/8
1½	7/16	1/16	1/16	1/32	1/64	1 1/32	1 1/2
1⅝	½	5/16	¾	1/16	1/64	1 1/32	1 5/8
1¾	17/32	21/64	13/32	1/64	1/64	1 1/32	1 3/4
1⅞	1/16	11/64	7/16	1/64	1/64	1 1/32	1 7/8
2	19/32	¾	15/32	1/64	1/64	1 1/32	2
2¼	11/32	27/32	1 3/64	1/64	1/64	1 1/32	2 1/4
2½	¾	15/16	1 15/32	1/64	1/64	1 1/32	2 1/2
2¾	29/64	1 15/32	1 15/32	1/64	1/64	1 1/32	2 3/4
3	33/64	1 1/8	1 19/32	1/64	1/64	1 1/32	3
3¼	31/64	1 7/32	1 23/32	1/64	1/64	1 1/32	3 1/4
3½	1 3/64	1 1/16	1 5/16	1/64	1/64	1 1/32	3 1/2
4	1 11/64	1½	1 25/32	1/64	1/64	1 1/32	4

Table XII

Values for Layout of 145-Tooth Gear or Rack*

Pitch	A	B	C	D	E	F	G
½	5/32	1/16	15/64	1/64	1/64	33/64	33/64
¾	7/32	3/32	11/32	3/64	1/64	33/64	33/64
1	1/16	3/16	15/32	1/16	1/64	1 1/64	1 1/64
1⅛	11/32	21/64	17/32	1/64	1/64	1 1/64	1 1/64
1¼	3/16	15/32	21/64	1/32	1/64	1 1/32	1 1/64
1⅜	13/32	23/64	21/64	1/64	1/64	1 1/32	1 1/32
1½	7/16	1/16	1/16	1/64	1/64	1 1/32	1 1/32
1⅝	½	5/16	¾	1/64	1/64	1 1/32	1 1/32
1¾	17/32	21/64	13/32	1/64	1/64	1 1/32	1 1/32
1⅞	1/16	11/64	7/16	1/64	1/64	1 1/32	1 1/32
2	19/32	¾	15/32	1/64	1/64	1 1/32	1 1/32
2¼	11/32	27/32	1 3/64	1/64	1/64	1 1/32	1 1/32
2½	¾	15/16	1 15/32	1/64	1/64	1 1/32	1 1/32
2¾	29/64	1 15/32	1 15/32	1/64	1/64	1 1/32	1 1/32
3	33/64	1 1/8	1 19/32	1/64	1/64	1 1/32	1 1/32
3¼	31/64	1 7/32	1 23/32	1/64	1/64	1 1/32	1 1/32
3½	1 3/64	1 1/16	1 5/16	1/64	1/64	1 1/32	1 1/32
4	1 11/64	1½	1 25/32	1/64	1/64	1 1/32	1 1/32

*The dimensions here given may be used for any gear with 145 or more teeth or for a straight rack.

THE FOUNDRY DATA SHEET, APRIL 15, 1919
Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

Why Expert Foundry Advice Sometimes Fails

Sound Advice to the Management of Casting Plants is Given by the Author Regarding the Employment of Experts and How They May be Aided in Their Investigations

By R R Clarke

THE true expert is one who knows the game in sum-total and in every detail. Mainly the expert's knowledge is derived from four distinct sources and is elaborated through his powers of comparison. These four sources are other men's experience, his own experience, experiment and his power to reason things out. Every true expert knows what other men have done and are doing, makes his own failures and accomplishments an inseparable part of his own life, tries different plans and methods to reduce doubts and establish certainties, and cudgels his brain for abstract conceptions of things that can be worked into result-giving practice. Without these, no expert knowledge can be gained and no claim to such distinction can long be set up. The expert, therefore, will appear not an idle dreamer or an imposter, as is sometimes believed, but instead a real, hard-working, constructive force.

Much of expert knowledge is common knowledge scattered among the mass of men. He stands at the head of men of his line, but not apart from them. No foundry expert in mixing, melting or molding has found the all of precedent is erratic or valueless. However advanced his ideas, they are not altogether his own, or distinctively apart from all previous suggestion. He knows by far more than the average man and considerably more perhaps than the mass of men taken together. What he does know is how to apply his knowledge to the best advantage. He is an expert not so much from what he knows, as how he knows and uses his knowledge. Of expert instruction we have frequently heard it said: "He didn't tell us anything we did not already know." Maybe not, but he did tell how to get the most out of that.

Expert Knowledge is Scientific

A further insight into expert knowledge will disclose its character of clearness and certainty as well as its deliberate qualities and its systematic order. To merit the distinction, this type of knowing must tend toward the scientific which is knowledge reduced and classified. Anything scientific is always clear and absolute, well arranged in the mind and applied to practice under a strong rationality and a judgment all but unerringly deliberate. The argument thus leads on to the conclusion first sighted, namely that in great measure the expert has merely the knowledge of the masses. The greatest difference, perhaps, is that he has this knowledge rounded-up, clearly conceived, defined and understood and a greater power for using it, and deriving additional truth from it. Did you ever struggle long with a foundry difficulty, finally solve it and then wonder at its simplicity? What could you see in the all of the solution, but that which should have appealed to you at the very beginning?

The Expert Sometimes Pioneers

But the expert is by no means always coincident with general knowledge and practice. Though often a follower of custom, he is nevertheless frequently a violator of precedent. The reason is he acts from an altogether different motive from the mass of men. These men do things in certain ways because men before them did them in those ways. Not so with the expert. When he follows established methods he does so because they satisfy his rational ideas; when those methods antagonize those ideas he abolishes custom and derives from that same rational source his better conceptions. Most men discern truth only at its risen splendor, a few catch its breaking light on the hilltops. Of these latter are the true experts.

Expert foundry advice is often sought and well it may be. Surely no field of human endeavor is more absolutely dependent upon correct method for results than this. It is one of those few items of industrial experience where the compass of truth is the only guiding instrumentality. The melter melts the metal, the molder closes the mold and pours it and what is done is done beyond recall. The great necessity of fundamental knowledge and practice is every day at hand in efficient founding.

The foundry world today has its true experts. Of these men let it be said that they are broad-minded, deep-thinking and generous and with knowledge and value high set, men who have come into their own by paying in full the price of possession. In the great majority of cases they give sound advice on foundry matters. Yet that advice is sometimes found not wanting, but failing. Why, is a natural question which we think can be naturally answered to the expert's complete vindication. Of course we must be understood to refer to the true expert and not to the mere pretender with title never legitimately established.

To clear up the situation involves a consideration of its elements. Of these there are quite a few. In the first place the expert has human nature against him. The rank and file of men are neither trained nor capacitated to recognize or appreciate the man who can straightforwardly do what they failed utterly to accomplish and they don't want to see that man do that. Secretly, they pray to their gods that his failure be as complete as their own. Now those are hard sayings yet sadly enough we believe them true. It is one of those deplorable streaks in human nature where lines converge to narrow space between them.

The Position of the Expert

All genius, all invention, all progress has had this element to contend with, the men who had never thought to, or had tried and failed to do something and for that reason stood squarely in the way of its doing by some one else. Such is the position of the expert. You engage him to get over some difficulty in your foundry that your talent at hand cannot solve. Among that talent you have an element of narrow, badly warped human nature. They have told you it couldn't be done and you didn't believe them. You told them it was being done other places and they didn't believe you. You have the man at hand to show them and they don't care to be shown. All this is a silent force, a masquerading opposition which you seldom detect and cannot consequently control. By it all the advantage of expert knowledge

and experience can be defeated. It takes co-operation on the part of workmen to get results from any supervision, and to deny that condition is to reduce to impotency the strongest effort, no matter what its status or source.

To sponsor the assertion that all cases, of necessity, include this opposition in its most acute form is not the conclusion we are striving to establish. The contention is, however, that every instance admits the possibility and that in a great number of cases from this possibility evolves a deplorable reality. The question then is this: How can the expert succeed, how can his advice function properly under conditions so adverse? Study human nature as some men possess it, learn the actual limits to which it sometimes carries them and the answer becomes at once plain, that he cannot succeed.

Give Him a Fair Chance

Again the expert is often not given a fair chance. This for more than one reason growing out of the peculiarities of the engaging party. When you engage an expert you cannot hold him to strict accountability, unless you meet his conditions and any result otherwise ensuing or judgment similarly pronounced, can have no standing before an impractical consideration of the case. Some executives think they have paid the full price of remedy when they engage the expert on his terms. That is often a mistake. The expert can only tell you the trouble and the remedy, advise you what to do and it's up to you to do it no matter what the cost may be. He may come into your foundry and find things fundamentally wrong. Conditions so illogical as to necessitate an entire change of arrangement, of equipment, of practice, etc. All that means a big outlay of capital and a serious temporary handicap to production. The question is, Are you going to make the sacrifice? If not, you may as well dismiss the expert for without his conditions met, he can be of little value to you.

Again, a temperament bordering on impatience may prevail. Lots of humans possess that trait. Usually an expert is not engaged until the executive has reached a breaking point in patience and is so utterly disgusted as to have completely demoralized his reserve. He wants results and he wants them quick. But he can't always get them; he cannot look for them. And if he don't get them he rails at the expert until his enduring powers give way. Now for a comparison. Suppose you developed sciatica. That's the result of a run-down, worn-out system. You engage a physician. He starts in to try to build up your system. It's a long, tedious process. Days go by, weeks perhaps, and your condition shows little change. Are you going to give up and fire the physician? Hardly. The base of many foundry troubles is hard to reach. It takes time to eradicate an evil which perhaps years have developed and have driven from bad to worse. The expert cannot do that in a day, and if you fret because of this until his own patience wanes and he desists from his unaccomplished task, you cannot justly say that he has failed.

Some men cannot unreservedly concede their own failures. They know their best efforts were barren of results, yet to admit the task their master, to confess their knowledge and ability wanting, does not lie within their compass. Their pride and their egotism are too strong for anything like that. The result sometimes is that when they put the task into another's hands, they expect him to do it, but insist that he do it their way. Under such handicap no man ever did, can or will accomplish anything worth while. The best thing for a foundry executive to do when an expert starts to work is to sink his pride and realize that his own ideas have been failing instrumentalities and to give the expert a free and untrammelled hand in order to get the full benefit of his superior knowledge and ability.

Of course it is all very well to acquaint the expert with what you did and did not do, to answer any and all questions he may ask, to offer suggestions subject to his disposal and to inquire into the whys and wherefores of his proceedings. These things are perfectly legitimate, but between them and the role of dictator is a wide distinction. The expert is the dictator and to reverse the order is to perpetuate the failing conditions. But at that the expert cannot be the whole show, nor can he do it all and to assume such is to reduce chances of complete success.

Trained Mind and Skilled Hand

Primarily, the expert is knowledge and thinking power. Fundamentally, skill is not a part of his essentials. The strongest combination in the foundry, to our mind, is a trained mind back of a skilled hand, but this condition exemplified in the same individual make-up is more ideal than real. Necessarily it presupposes a division of the individual's time and attention by which efficiency in both particulars generally is lowered. Only a few are given the aptitude to become masters in both spheres in the allotted time. Now if these reasonings be just, the conclusion is at once plain that the expert on any occasion needs high-class, intelligent, practical help. He needs help from men who know the practical end and can grasp and apply readily and intelligently the expert's ideas. On any hard case any physician will rely and credit to the limit the common sense care, the intelligent interpretation and the faithful carrying out of his instructions. If this were not true, trained nursing would be unknown in the world today. After all, a foundry difficulty is a matter of cure, or if you like, of remedy. Only those who have worked with dull, noncomprehensive, mechanically poor help know the tremendous handicap it inevitably entails. The late Elbert Hubbard sponsored the statement that some men get results if kindly encouraged, but give us the man who can do things in spite of hell. That is a very lofty sentiment and we admire the man who has done and can do that thing, but from hard experience we know a little of his toil and trouble.

Opposition from Practical Men

Between the man of knowing and the man of doing, that is, between the practical and the technical man, there seems to be a lurking opposition generating and perpetuating from the practical side. Time and again we have noticed this spirit called forth from practical men in mere conversation. The 1916 Foundrymen's convention in Cleveland furnished a striking example when the dean of a great technical school in convention discussion had to defend his principles against a strong wave of attack from practical men in the house. That is a disadvantage against which the expert often has to contend and it certainly is a power against him. In it lies a great destructive force to wholehearted co-operation. And this co-operative factor denied, greatly complicates the situation and reduces in effect the constructive energy. Experts are human and plastic, susceptible to all the influences that bear upon them in their appointed tasks and confidence in them is a wonderful stimulus to them. Have you ever noticed that the great majority of men are more interested in destruction than in construction? Happen around where a building is being torn down and you will always find a crowd of interested on-lookers. See one going up and you will find a smaller crowd and

less interest. It's the reversal of this principle that you want to work to when you engage an expert.

The average man does not fully appreciate detail. To the expert detail is everything. He despairs of all composite harmony unless each separate part is carefully attended to. And that is the logic of all master thought, the guiding principle of all excelling skill. The primary difference between a good picture and a bad picture, a good system and a poor system, a good molder and a mediocre molder, a good casting and a bad casting is all largely a matter of detail. But the mass of men seem to have never learned that lesson nor trained their thought to appreciate its significance. To them general principles are more attractive than particulars and of far greater value. Such is not the case. Generals mark the outline, but particulars complete the form. No general instructions are worth their breath of telling without their supporting particulars. Expert advice is always exhaustive of detail. Read the answers to the questions in the trade publications and note the many little details that are honored, things apparently too trifling to mention, yet which the author of the answer feels to be a part of the eternal fitness. No great failure ever occurred in a foundry that did not trace to a neglect of one or more particulars. Every true expert knows this and makes it an inseparable part of all his investigation. What can he deal with them in advising as to remedy, but these little co-ordinating details so often and disastrously overlooked? And it is foundry wisdom to accept these small particulars at value assessed. You may do everything you are told except one little thing and by that very single omission spoil the whole affair. And if you do, are you going to lay it to the expert and say he didn't know what he was talking about?

The sum total of the argument is: Give the expert a fair chance. If he succeeds, give him credit; if he fails, consider yourself stung. But chances are you will seldom have occasion to thus discredit your judgment in selecting him to help you out.

How Core and Parting Compounds Are Made

THE Holland Core Oil Co., 4608 West Huron street, Chicago, has completed a new plant equipped to produce core oil, core compound and parting compound. The building is 75 x 120 feet. A further building is to be erected, 50 x 120 feet, which, together with storage tanks for oil, will occupy the remainder of the site.

Parting compound is produced by calcining tripoli, properly treated with dissolved fat, in a kiln revolving over a gas flame, thoroughly mixing the material. The kiln is of steel plate, 24 feet long and 36 inches in diameter inside. The treated tripoli is shoveled into a hopper from which a screw feed 6 inches in diameter and 3 feet 6 inches in length delivers it into the kiln. At the delivery end the material passes onto a 120-mesh screen. Under the kiln is a series of gas burners by which the temperature is held uniform, the heat being regulated by an arbitrary rule based on the actual consumption of gas as indicated by meters in plain sight of the operator. Frequent tests are made to determine the condition of the material.

In packing the parting compound, paper lined barrels are used, and each scoopful is placed in a different barrel in succession, thus allowing the parting time to cool somewhat before the next scoopful is put in the same barrel. This tends to reduce the danger of its becoming solidified by action of the contained heat.

In the manufacture of core oil, uniformity of product and high binding efficiency are the principal factors sought. In the production of the oil, which is carried on in a fireproof building, five kettles heated by gas flames are utilized. Two kettles are of 30 gallons, two of 25 gallons and one of 15 gallons. The total capacity of this unit is 103 barrels of complete oil in four hours.

Experiments, according to the Holland company, have indicated that while resin will give a bonding efficiency of 15 to 1, whether melted or dry, they also show that after the resin is heated to a high temperature in a specially constructed closed kettle, the brittleness is removed and a gum results which gives a bonding ratio of 25 to 1, one part of the resin gum holding 25 parts of sand. The oil which enters into the core oil with the resin is heated in kettles and jets of air are blown through it. This oxidizes the oil and gives it a much heavier body.

The kettles are heated by gas mixed with air under pressure. A safety cut-off operates to close the gas main as soon as the air pressure drops, thus preventing the possibility of an explosion resulting from the gas continuing to flow under the kettles without the compressed air to support combustion. This is brought about through the use of a diaphragm which is held in position while the pressure is on, but springs back and closes a valve when the pressure drops. Recording pyrometers are used to register the heat under each kettle and the latter are provided with water coils by which temperature may be brought down if it runs too high.

A laboratory is operated in connection with this plant where tests are made of raw material entering into the production and also of the products themselves. A recent development of the laboratory is the production of a dark core oil, which has special qualities.

Gray Iron Mixture for Grate Bars

By H. E. Diller

Question:—We manufacture grates for locomotives, our mixture consisting of 70 per cent railroad scrap, other than burnt grates, and 30 per cent pig iron. The analysis of the mixture follows: Silicon, 2.59 per cent; sulphur, 0.014 per cent; phosphorus, 0.45 per cent and manganese, 0.71 per cent. Some of our customers report to us that the grates are not giving satisfaction on locomotives using stokers.

Answer:—The mixture for grate bars should be comparatively high in sulphur and low in silicon. Such a mixture will be high in combined carbon and a high percentage of sulphur will have a tendency to retain the carbon in its combined form. In the combined state, the carbon will burn out less rapidly than when it is in the form of graphite and the iron carbide is less readily oxidized than the free iron. Therefore, such an iron is not so easily burnt. An off pig iron, high in sulphur and containing from 1 to 1.50 per cent silicon, will be cheaper than the pig iron that you are using and will give you a better mixture for grate bars, although the amount of silicon in the pig iron finally would have to be determined by the amount of silicon in the scrap.

The grate bars should analyze as follows: Silicon, 1.25 to 1.50 per cent; sulphur, 0.15 to 0.25 per cent; phosphorus, approximately 0.5 per cent, and manganese, 0.40 to 0.80 per cent.

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A Word from the Publisher

By John A Penton

THE hour has come when the growth of the foundry industry in all parts of the world compels a marked increase in the character of the service required from this publication. Contrary to the general belief, there is no section of the iron industry which has progressed more in 20 years than the foundry business.

In none have the new appliances, systems and methods reflected greater improvement and every phase of the industry is still going through an era of rapid development. In all this movement, THE FOUNDRY has been the mainstay and every well informed, thinking man readily gives this publication credit for its wide measure of influential effort and for much of the achievement of three decades.

But the industry is no longer a once-a-month affair.

A once-a-month magazine will not serve.

Hence, with this issue THE FOUNDRY becomes a semimonthly.

We feel confident that this appreciation of the industrial development of the business we all are seeking to serve will bear fruit in stimulating further progress, greater achievements and increased prosperity in the foundry field.

Malleable Records Big Gain

PIG iron production last year again passed 39,000,000 tons, but it was about 400,000 tons less than the record year of 1916. The total production, as reported by the American Iron and Steel institute, was 39,051,991 tons, as compared with 39,434,797 tons in 1916. Due to the restrictions placed on foundry pig iron manufacture the greater part of last year, the total was nearly 200,000 tons less than in 1917. The production of this grade and ferrosilicon in 1918 was 5,142,607 tons as compared with 5,328,258 tons the previous year. On the other hand, malleable pig iron production increased more than 100,000 tons. The total for 1918 was 1,117,914 compared with 1,015,579 tons in 1917.

The largest recorded production of foundry iron was in 1916, when 5,553,644 tons was reported, but 1918 is the record year for malleable pig iron output. In 1900, 173,413 tons of malleable pig iron were made and since that time the output has increased sixfold.

It is noted that in 1900 the foundry iron total was 3,376,445 tons, whereas last year it was 5,142,607 tons; the comparative growth of the malleable iron industry in this country is reflected by the small increment of foundry iron output. The underlying reason for this tremendous increase in malleable pig iron production is the improvement in this cast product, which has been particularly noticeable in recent years. From the figures available for steel casting production in 1917 which was 1,441,407 tons, it becomes apparent that the malleable iron industry is rapidly approaching the total of that of the steel casting trade. From the figures at hand, the foundry pig iron output has not increased materially in the last decade. In 1908 the total production was 5,322,415 tons, which exceeds that of last year, and even 1910 with 5,260,447 tons, is indicative of the comparatively stationary situation, in point of production, of the gray-iron industry. On the other hand, both the malleable and the steel casting branches of the trade have made tremendous strides and here principally is recorded the growth of the casting industry of the United States in recent years.

Trade Outlook in the Foundry Industry

AUTOMOBILE production with its demands reaching all classes of casting plants continues to be the strong factor in sustaining foundry operations in the Central West. Those jobbing shops which are handling automobile and tractor work are engaged to capacity, and some in fact are refusing additional orders. Truck, tractor and pleasure car construction all are exceedingly active and seem not to be affected by prevailing price uncertainties. Light gray-iron shops and malleable plants are benefited by these conditions to a greater extent than the steel foundries. Brass and aluminum shops note an increase in orders due to the automotive industry. The return to aluminum for parts which were made of iron or steel during the war, and the growing use of bronze bushings and bearing alloys since the demand for conservation has been removed is affecting nonferrous casting activities to a marked degree in the past few weeks.

Pig Iron is a Barrier

Prevailing uncertainties in the price of pig iron and the inability to forecast with assurance the trend of the market in the near future is clogging the flow of foundry business. With inquiries being held back in expectation of a lower level, foundrymen hesitate to quote prices for castings which would involve covering on iron requirements. Although the price adjustment effective March 21 was not made retroactive by official statement, a great many deliveries are being made on old contracts at the new prices. Foundries in Ohio have protested against the application of the valley base to iron delivered on new contracts. This has resulted in the quotation of a straight price of $26.75 on No. 2 foundry in that district. Furnace operation continues to decline, and practically all makers are piling iron. The lowering of price was intended to stabilize the situation but the resultant discussion has tended rather to disrupt confidence and to deter any buying movement. Foundries in general are covered, but excepting those in a few lines are not offering specifications far in advance of immediate needs.

Prices of Raw Materials for Foundry Use

CORRECTED TO APRIL 11

Iron	
No. 2 Foundry, Valley	$26.75
No. 2 Foundry, Birmingham	26.75
No. 2 Foundry, Chicago	26.75
No. 2 Foundry, Philadelphia	30.65
Basic, Valley	25.75
Malleable, Chicago	27.25
Malleable, Buffalo	27.25

Coke	
Connellsville foundry coke	4.75 to 6.00
Wise county foundry coke	6.50 to 7.00

Scrap	
Heavy melting steel, Pbgh.	$16.00 to 16.50
Heavy melting steel, Chicago.	16.50 to 17.00
Stove plate, Chicago	18.00 to 18.50
No. 1 cast, Chicago	23.00 to 24.00
No. 1 cast, Philadelphia	22.00 to 23.00
No. 1 cast, Birmingham	18.00 to 20.00
Car wheels, iron, Pittsburgh.	22.00 to 23.00
Car wheels, iron, Chicago	20.50 to 21.50
Railroad malleable, Chicago.	18.50 to 19.00
Agricultural malleable, Chicago	17.25 to 17.75

Mallerable is Recuperating

Operations in malleable plants continue at or near 70 per cent of capacity. Directly affected by the increasing volume of automobile activity, this division of the casting industry is in general experiencing but little slackness from the dearth of railway business. The feeling is generally expressed that both the agricultural implement trade and railway buying may be expected to bring operations up to capacity soon. Further demands for electrical apparatus and pipe fittings also are expected to bring a strengthening influence to bear coincident with the revival of building operations. That building is slowly recovering is attested by the mounting curve of orders for structural steel and construction materials. This later will influence malleable castings production. No new malleable plant construction is reported. Railway buying is expected in volume following the settlement of the controversy relative to prices in other lines.

Gray Iron Mottled

Gray iron foundries handling automotive work of all classes are active. The tractor industry which has expanded steadily is supplying a large field for the sale of cylinder, flywheel and miscellaneous castings. The scope of this work was graphically illustrated recently by the slackening to about 40 per cent production when in six large foundries a single large manufacturer suspended his output of over 200 tractors per day pending stock taking and discussion of minor changes in mechanical details. Machine tool builders are offering little new business to the foundries, as practically all activity in machine tool lines is confined to used machinery released to the market through the shift to peacetime operations. Automotive demands coupled with the continuation of marine work has served as a buffer for the manufacturer of heavy gray-iron castings. Lower prices on boilers and radiators are offering a slight stimulant to demand. Cast-iron pipe makers in the Birmingham district report an increase in business since the first of the month, and inquiries are developing as state and municipal bodies endeavor to start public work to prevent idleness among labor ranks. A revival is apparent in stove-foundry operations, but except for this feature, standard gray-iron plants are not heavily engaged.

Brass and aluminum foundries depending upon marine or automobile work are active. Casting copper is quoted at 15.25c to 15.37½c, New York. Prices of other nonferrous metals, based on New York, are as follows: Lead, 5.25c; tin, 72.50c; antimony, 6.50c to 6.75c, and aluminum, No. 12 alloy, producers' price 33c, and open market 24.50c to 25c. Spelter is quoted 6.30c to 6.35c, St. Louis. The price range of nonferrous casting metals was lower for March than for February as may be noted from the following table:

	Copper	Lead	Spelter	Antimony	Aluminum
March	15.91	5.25	6.186	6.80	25.67
February	18.23	5.12	6.35	7.21	27.65

Foundry equipment manufacturers report a fair volume of business, indicating a condition of optimism regarding future business. Many foundries are using the opportunity to replace machinery racked under war service, and unavailable for installation immediately following the armistice.

COMINGS AND GOINGS OF FOUNDRYMEN

Nelson B. Gadch has been made district manager of sales for the Chicago Pneumatic Tool Co., at Minneapolis.

James A. Murphy has resigned as foreman of the Russell & Erwin Mfg. Co. division of the American Hardware Corp., New Britain, Conn.

Joseph L. Tillman has been elected vice president and manager of the Maumee Malleable Castings Co., Toledo, O.

James H. Anderson has resigned his position as foundry superintendent for the C. S. Bell Co., Hillsboro, O., to become general superintendent of the Root-Heath Mfg. Co., Plymouth, O.

Stuart B. Marshall, Roanoke, Va., consulting engineer and metallurgist, has established headquarters at Chevy Chase, Washington, retaining his Roanoke address.

Louis J. Schneider has been made Detroit agent for the Harrison Radiator Corp., Lockport, N. Y., with offices and sales rooms at 3066 West Grand boulevard.

Ian F. Panton, a director of Ley's Malleable Iron Works, Derby, England, is visiting and inspecting the large malleable plants of the United States.

W. B. Thurston, formerly affiliated with the Reo Motor Car Co., Lansing, Mich., has been made superintendent and chief millwright of the Akron Brass & Foundry Co., Akron, O.

H. F. Paddock has been appointed purchasing agent of the Saginaw Malleable Iron Co., Saginaw, Mich., a division of the General Motors Co. Until recently Mr. Paddock was mayor of Saginaw.

John Blair, who resigned recently as general foreman of the Union Steel Casting Co., Boston, has accepted a position as assistant superintendent of the New England Steel Casting Co., Springfield, Mass.

Werner G. Smith, president of the Werner G. Smith Co., Cleveland, addressed the monthly meeting of the New England Foundrymen's association that was held in Boston, April 9. His subject was "The Theory and Practical Application of Core Binders."

J. M. Barringer has been appointed manager of the Flint Foundry Co., Flint, Mich., specializing in the production of automobile castings. Mr. Barringer formerly was general superintendent of the American Malleables Co., Lancaster, N. Y., and more recently was manager of the Timken-Detroit Axle Co.'s foundry at Canton, O.

James Shattuck, who is British sales representative for the Norton Co. and the Heald Machine Co., Worcester, Mass., through the firm of Alfred Herbert, Ltd., Coventry, Eng., addressed the advertising club of Worcester recently on the foreign trade possibilities and methods of selling.

R. L. O'Connor, of the Rex Tool & Machine Co., Detroit, has been elected vice president of the Pontiac Workers' Mutual association, recently organized at Pontiac, Mich. Elmer E. Blackstone of the Wilson Foundry & Machinery Co., is a director.

E. Eklund has been made special foreign representative of the Chicago Pneumatic Tool Co. and will leave for Europe in the near future to take up his new position. He is succeeded as manager of the rock drill sales division by J. I. Edwards.

J. E. Slimp resigned April 1 from the sales department of the Ohio Brass Co., Mansfield, O. He will become associated with H. C. Dodge, of Boston, who is at the head of several manufacturing companies in New England.

Fred E. Russell, formerly president and owner of the Aetna Foundry & Machine Co., Warren, O., now is associated with Shields Burr, as Russell & Burr, Land Title building, Philadelphia, contracting, industrial and sales engineers.

John B. Canfield has been made special representative for the Harley Co., Springfield, Mass., manufacturer of brass and aluminum castings. Mr. Canfield recently was discharged from the service with the rank of major of engineers. He formerly was master mechanic of the Boston & Albany railroad.

A. O. Backert, president of the American Foundrymen's association and vice president of The Penton Publishing Co., Cleveland, sailed for Europe on the AQUITANIA, April 5. While abroad Mr. Backert will extend an invitation to the foundrymen of England, Scotland, Ireland, Belgium and France, to attend the internatoinal convention and exhibition of the American Foundrymen's association, which will be held in Philadelphia during the week of Sept. 29.

F. S. Healey, chief engineer, Epping-Carpenter Pump Co., Pittsburgh, in addition to his other duties has assumed the management of the sales of this company. F. F. Woods, former manager of sales, now is located in New York in the capacity of eastern sales manager. Albert A. Scheuch has been appointed assistant manager of sales and Paul D. Goodman, formerly affiliated with the McClary, Jamison Machinery Co., Birmingham, Ala., has been added to the sales force.

F. T. Dickinson, formerly superintendent of the Railway Materials Co.'s foundry at Toledo, O., has been appointed general manager of the new plant of the Colorado Brake Shoe & Foundry Co., Denver. Mr. Dickinson was affiliated with the Railway Materials Co. for 10 years and during this period he started and operated the plants of this company located at Phoenixville, Pa., and Stevens Point, Md. The Colorado Brake Shoe & Foundry Co. is modernly equipped throughout and has a capacity of 50 to 60 tons daily.

C. O. Miniger, vice president in charge of production of the Willys-Overland Co., Toledo, O., has resigned to devote his entire time to the affairs of the Auto-Lite Co., of which he is president and general manager. However, he continues as a director of the Willys-Overland Co. He will be succeeded by Leroy Kramer, vice president in charge of manufacture of the Pullman Co., Chicago, who for the past six months has been manager of the southwestern district of the United States railroad administration, with headquarters at St. Louis. Mr. Kramer has been elected vice president of the Willys-Overland Co. in charge of production. C. R. Miller, who has been assistant to Mr. Miniger, has been appointed works manager of the Toledo plants of the Willys-Overland Co.

Lieut. Col. Thomas F. Brown, who recently secured his release from the United States army, has become affiliated with Butler & Hayes, Inc., industrial engineers, Boston, in the capacity of vice president and general manager. After the declaration of war with Germany, Col. Brown was

commissioned major in the ordnance department and was designated as commanding officer of the school for instruction of ordnance personnel at Watervliet arsenal. Subsequently, he was sent to France and England to make a study of transportation, storage and issue of explosives from the factories to the front line trenches. Col. Brown has had many years of experience as metallurgist at Watertown arsenal and in 1912 he was sent abroad by the government to investigate methods of steel and foundry practice with particular reference to the Hatfield process of manufacturing armor-piercing projectiles and other methods of producing shell forgings. After leaving the government service in 1916, he accepted a position as superintendent of the Framingham Foundry Machine Co., Framingham, Mass., which manufactured English and Russian projectiles and other foundry products.

Patrick Dwyer

Patrick Dwyer, well known in the foundry industry through his writings on technical subjects, has become affiliated with THE FOUNDRY. Mr. Dwyer recently resigned as foundry superintendent of the Sydney Foundry & Machine Works, Ltd., Sydney, Nova Scotia, a position which he held for the past eight years in order to become connected with this publication. Previous to that time he was superintendent for the Dominion Iron & Steel Co., of the same city. Mr. Dwyer's experience covers over 20 years in iron, steel and brass foundries of the United States and Canada, and during a great part of this time he has been a writer of articles on foundry and other subjects.

Form Organization of Electric Furnace Interests

Representatives of electric furnace interests at a meeting in Niagara Falls, N. Y., on March 21 and 22, effected an organization which has for its object gathering and disseminating information on subjects relating to electric steel. This meeting was called by Acheson Smith, vice president and general manager of the Acheson Graphite Co. Mr. Smith, in his preliminary statement at the meeting, outlined the importance of furnishing consumers of electric furnace products with data and information on methods of manufacture. The tonnage of electric steel, which has shown remarkable growth during the past four years was commented upon and credit was given to quality of product and economy of manufacture of this class of steel.

Resolutions were passed inviting all manufacturers of electric furnaces, and related electrical apparatus, supplies and accessories; public utility corporations supplying current; designers; inventors and users of electric furnaces to become members of the new association. A strong working nucleus for the organization was formed through the concerted action of those who attended. Representatives from a large number of companies were present. Among them were the following: L. S. Thurston, C. A. Winder, G. Campbell and J. A. Seede, General Electric Co., Schenectady, N. Y.; C. J. Schluederberg, J. L. McK. Yardley, C. B. Gibson and R. P. Chase, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.; F. J. Ryan, American Metallurgical Corp., Philadelphia; F. T. Snyder and F. Von Schlegell, Industrial Electric Furnace Co., Chicago; C. A. Vom Baur, T. W. Price Engineering Co., New York; C. H. Booth, Booth-Hall Co., Chicago; H. A. DeFries, Hamilton & Hansell, New York; R. J. Paulson, Ludlum Electric Furnace Co., New York; W. E. Moore, Pittsburgh Electric Furnace Co., Pittsburgh; F. A. Fitzgerald, Fitzgerald Laboratories, Niagara Falls; F. J. Tone, Carborundum Co., Niagara Falls, N. Y., and Acheson Smith, E. G. Acheson Jr., W. H. Arison, H. P. Martin, S. L. Walworth, A. M. Williamson, P. D. Steuber, J. F. Callahan, E. B. Drake, L. C. Judson, and A. B. Oatman, Niagara Falls.

The new organization will be called the Electric Furnace association. The officers chosen, follow: President, Acheson Smith, Acheson Graphite Co., Niagara Falls, N. Y.; first vice president, C. H. Booth, Booth-Hall Co., Chicago; second vice president, W. E. Moore, Pittsburgh Electric Furnace Co., Pittsburgh; secretary, C. G. Schluederberg, Westinghouse Electric & Mfg. Co., Pittsburgh, treasurer, F. J. Ryan, American Metallurgical Corp., Philadelphia. The directors elected were the officers and C. A. Winder, General Electric Co., Schenectady and F. J. Tone, Carborundum Co., Niagara Falls, N. Y.

The next meeting will be held in New York within the next few weeks.

Welding Society Formed

At a meeting held in New York on March 28 the ground work was laid for a new technical organization which will study and develop welding in all its branches. This body which will be known as the American Welding society, will co-operate with existing organizations in the advancement of all forms of welding. The officers elected to head the society are Comfort A. Adams, president; Howard C. Forbes, secretary; and W. E. Symons, treasurer.

Testing Society to Meet in June

The twenty-second annual meeting of the American Society for Testing Materials will be held at the Hotel Traymore, Atlantic City, June 24 to 27. The papers committee has in preparation a comprehensive program which will be issued in the near future. The present membership of the society is 2372 as compared with 2261 at the last annual meeting.

OBITUARY

Capt. Ira E. Hicks, formerly superintendent of the New Britain Malleable Iron Works, New Britain, Conn., died at his home in that city, March 28, aged 79 years.

Harold H. Nutter, treasurer, Noyes & Nutter Mfg. Co., Bangor, Me., maker of stoves and ranges died at his home in that city on March 13, aged 36 years. He had been connected with the company since his graduation from Bowdoin college in 1905.

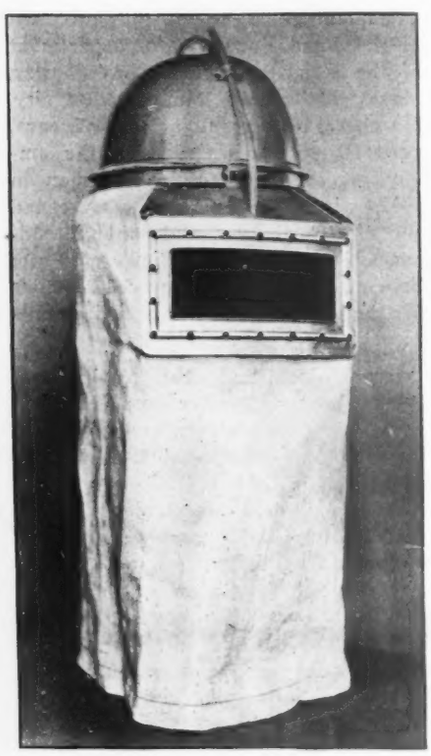
William A. Kenney, superintendent of the Reed Foundry Co. department of the Reed-Prentice Co., Worcester, Mass., died at his home in that city, March 23, as a result of the influenza, aged 60 years. He entered the employ of the company as foreman in 1902, when the foundry was opened and afterwards was made superintendent. He held that position up to the time of his death. He was a member of the New England Foundrymen's association.

John Gilson Sr., Port Washington, Wis., pioneer founder and machine shop owner and widely known as the inventor of the adjustable chair iron which made possible the revolving office chair, died March 23, aged 70 years. Mr. Gilson was born in Milwaukee. His father established one of the first foundries and machine shops at Port Washington in 1854, later taking the son into partnership and operating as Theodore Gilson & Son. Upon perfecting the chair iron, the business was incorporated as the Gilson Mfg. Co. in 1893. Ten years ago Mr. Gilson disposed of his interest to Harry W. Bolens and asso-

ciates. More recently Mr. Gilson and his son, John E. Gilson, conducted the J. E. Gilson Co., Port Washington, manufacturing malleable and gray iron castings, garden tools and specialties.

Makes New Aluminum Helmet

The rapid development and widening service of sand blast machines has been matched by progress in safety and comfort accessories. Sand blast helmets which protect the workman's eyes and face have immeasurably added to the progress in the use of sand blast equipment. Recently a helmet has been produced which is made of aluminum. This metal is used to provide lightness and protection from rust or corrosion. It is stated that hot water or steam may be used to sterilize the helmet after a day's work, to prevent the chance of disease transmission. A wide opening is allowed so that the operator may have a clear vision of his work. As may be seen from the accompanying illustration, the crown or main body is made from sheet aluminum. The protecting curtain is heavy canvas, held in place by a clamping band, so that it may be removed and replaced. It is so constructed that a small rubber hose, which enters the front portion of the helmet may be attached to the compressed air line, admitting a limited amount of air under pressure, and serving to prevent the entrance of any dust, smoke or gases to the helmet.



NEW HELMET FOR SAND BLASTING HAS ALUMINUM FRAME

Prepares Semisteel Booklet

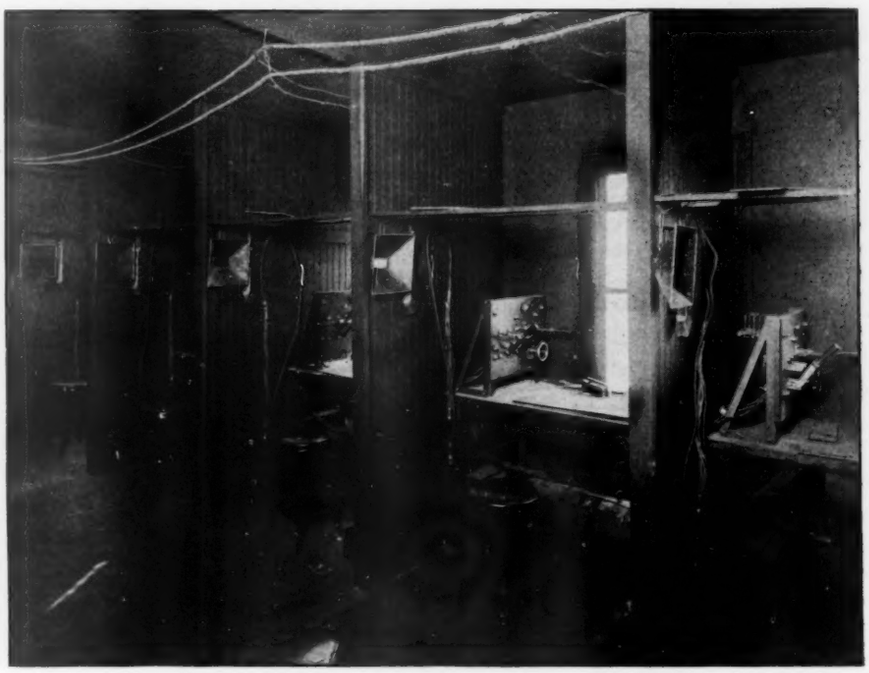
An extremely interesting publication called "McLain's Semisteel" has been prepared by McLain's System, Inc., Milwaukee. The development of a metal made through the mixing of steel with iron in the molten state is traced from its earliest inception to its present wide acceptance in this country and abroad. The story of semisteel in the war, particularly the part played by this metal in France's hour of need, is told in detail. The greater portion of the publication is given over to the varied applications of semisteel and its value in peace-time industrial uses.

To Make High-Speed Cast Steel

The Liberty Steel Corp. is constructing a plant at Morristown, N. J., on property recently acquired for the manufacture of high-speed cast steel. A 1000-pound Renerfelt electric furnace is being installed by Hamilton & Hansell, 21 Park Row, New York.

Continues Higher Course in Electric Welding

Attention first was focused upon the practical value of electrical arc welding in its larger application, by the service of this apparatus in repairing the interned German liners. Immediately following our entrance into the war, these ships which had been wantonly damaged by their crews, were put into operating condition through the use of the electric arc welder. Following this, throughout the war, the value of welding equipment in construction as well as in reclamation and repairing became increasingly appreciated. Schools were established to train men who were badly needed to use the electric welders in the foundries, shops and shipyards throughout the country. The Lincoln Electric Co., Cleveland, was one manufacturing interest which undertook to teach untrained workmen this art. The school established by this company taught the use, scope of service and care of electric welders under the management of skilled operators. A view of the equipment and apparatus installed to carry on this work accompanies. The work of the school has proved to be so valuable that it has been continued, and its services placed at the disposal of manufacturers.



STALLS COMPLETELY EQUIPPED WITH SWITCH BOARDS, ELECTRIC ARC WELDERS AND AUXILIARY APPARATUS AID COMPETENT INSTRUCTORS IN TEACHING UNTRAINED MEN AT THE LINCOLN ELECTRIC CO., CLEVELAND

Disposing of the Slag When Melting Continuously

By G. R. Brandon

Question: When melting more than 30,000-pound heats in the cupola, we experience considerable trouble in disposing of the slag. The cupola is lined to 44 inches at the melting zone. The slag comes down through the bed with the iron and the blast striking it chills it, with the result that it forms a bridge below the melting zone, seriously impeding the flow of the molten iron. We charge the cupola with coke and coal, using a bed of coke for rapid ignition and

coal on top of that to a height of 24 to 27 inches above the tuyeres. The first charge of iron contains 3000 pounds of metal. The charges after that are maintained at a ratio of 10 to 1, namely, 3000 pounds of iron to 300 pounds of fuel. We get hot iron and the heat runs off smoothly until 28,000 or 30,000 pounds of metal have been tapped out. We also use 80 pounds of limestone to each charge. Kindly let us know how we may overcome this difficulty.

Answer: If the coke used is of good quality, averaging from 10 to 12 per cent ash, you undoubtedly are using an excessive amount of limestone. Instead of 80 pounds of flux, we recommend from 40 to 60 pounds for 3000 pounds charges of iron and we suggest further that the quantity of flux be reduced gradually and the results noted until the proper practice is obtained. Limestone should not be added until the third or fourth charge.

To prevent the chilling effect of the blast, block-off the lower tuyeres 10 to 12 inches each side of the slag hole, and if the upper tuyeres are being used, block-off the one directly over the slag hole, if one happens to be located at this point. You probably will increase the fluidity of the slag by reducing the upper charge of iron to 2000 pounds and reducing the coke to 200 pounds with a proportionate decrease in the amount of flux. This will insure greater continuity of operation. In recent months the coke produced has not been up to the standard, the ash sometimes being double what it should be and, therefore, more flux is required than ordinarily, but this apparently is not the cause of your trouble.

The Moltrup Steel Products Co., Beaver Falls, Pa., manufacturer of cold drawn steel shafting and screw steel, finished machine keys, finished steel plates and other specialties, has established a branch office in the Woolworth building, New York, in charge of J. J. Callahan.

WHAT THE FOUNDRIES ARE DOING

Activities of the Iron, Steel and Brass Shops

The Reading Casting Co., Reading, Pa., contemplates the erection of a plant addition.

The erection of a foundry, 60 x 100 feet, is contemplated by F. H. Server, Marine City, Mich.

Hunt, Hoalm & Farris, Harvard, Ill., are reported contemplating erecting a foundry, 50 x 250 feet.

A foundry addition is being erected at the machine shop of A. J. Drews, Roseburg, Oreg.

Construction of a foundry is contemplated by the Kelsey Wheel Co., 1230 Military avenue, Detroit. John Kelsey is president of the company.

Work will be started soon by the Canion Airbrake Co., Baltimore, on a 1-story, 100 x 250-foot foundry, pattern shop and machine shop.

George H. Evans, Philadelphia, is preparing an estimate for a foundry at Juniata and Roxsborough avenues, Philadelphia.

An addition to the foundry of the Portage Iron Works, Portage, Wis., will be erected shortly. A. R. Slinger is the head of the company.

The Ruddy Furnace Co., A. E. Rudolph, president, Dowagiac, Mich., plans the construction of an addition to its foundry, 50 x 200 feet.

The construction of a large plant addition has been completed by the Pacific Car & Foundry Co., Portland, Oreg.

Otto E. Kavieff, 712 Empire building, Detroit, is drawing plans for the construction of a foundry. The owner's name is withheld.

A foundry addition, 70 x 80 feet, will be erected by the Brownwall Machine & Pulley Co., Holland, Mich., if present plans of the company mature.

The H. & H. Foundry Co., Stamford, Conn., is reported planning the construction of two foundry buildings, both 60 x 200 feet.

Construction of a plant addition is reported being planned by the Maumee Malleable Castings Co., Woodville avenue, Toledo, O.

The Carnegie Steel Co., Sharon, Pa., plans to rebuild its carpenter and pattern shops which were recently damaged by fire.

The Erie Malleable Iron Co., Erie, Pa., will have plans prepared for the erection of an addition, 40 x 60 feet.

Plans are being prepared for the erection of a foundry for the Century Iron Co., 1453 Niagara street, Buffalo.

An extension to the foundry of the Skandia-Pacific Oil Engine Co., Oakland, Cal., is being planned. The building will be 150 x 260 feet.

Offices and works have been opened at 242 Clarke street, Montreal, Que., by the Montreal Pattern Works, under the management of George Underwood.

Henry Alldis, Chehalis, Wash., is reported planning to erect a new building which will double the capacity of his foundry. He will also erect a pattern shop.

The F. E. Golian Co., foundry and ornamental iron worker, Alene avenue, Atlanta, Ga., plans to triple its capacity. F. E. Golian is president.

The Studebaker Corp., South Bend, Ind., has plans for a foundry, 125 x 500 feet, forge shop, assembling works, carbonizing shop and other structures.

Charles G. Ferrell, 3938 South Broadway, Los Angeles, heads the Ferrell Brass Foundry, 110-12 East Seventeenth street, which was recently organized to manufacture brass and bronze castings.

The Youngstown Foundry & Machine Co., Youngstown, O., is reported planning the construction of a steel foundry at Girard, O. Building operations will be started soon. W. J. Wallis is president.

Plans have been prepared for the construction of a pattern shop, 1-story, 40 x 70 feet, for the Modern Pattern Shop, 3241 Thirtieth street, St. Paul, Minn.

Preliminary estimates for the construction of a foundry, 28 x 115 feet, are being made by the Wilmington Casting Co., Wilmington, O. E. R. Bales is president of the company.

The construction of a building to replace one recently damaged by fire, is planned by the B. Hoffman Mfg. Co., 257 Sixth street, Milwaukee, which operates a foundry and machine shop.

The Safety Cover Co., New York, foundry, factory and railway equipment, recently was incorporated with $50,000 capital, by C. W. Abbott, S. Alpert and F. A. Kapp, 1463 Broadway, New York.

A contract has been let by the March-Brownback Stove Co., Pottstown, Pa., to Frederick H. Keiser & Co., 123 East Fourth street, Pottstown, for the erection of a foundry addition, 60 x 60 feet.

An increase in capital from $100,000 to $200,000 recently was made by the Decatur Malleable Iron Co., Decatur, Ill., doing a general foundry and machine shop business.

Plans are being figured for the erection of a foundry, 100 x 180 feet, for the Marlin-Rockwell Co., New Haven, Conn. The building will be of brick and steel construction.

The Hub Electric Steel Casting Co., Boston, recently was incorporated with $90,000 capital, by Charles Van Stone, South Boston, Mass., Charles V. S. Paul and E. P. Van Stone.

A new building will be erected by the Newark Stamping & Foundry Co., Newark, O., which recently purchased the equipment of the May-Fiebeger Co., Akron. O. E. F. Ball is general manager.

Installation of new brass furnaces and other equipment is planned by the Ideal Metal Co., 1212 West Liberty street, Cincinnati, which company recently increased its capital.

The Louisville Pattern Works, Louisville, Ky., was recently incorporated to manufacture patterns for automobile parts. John F. Reeder, Muncie, Ind., is one of the incorporators.

The plant of the Perseverance Iron Foundry, Latona street and Passyunk avenue, Philadelphia, recently was damaged by fire. Many patterns and new machinery, recently installed, were damaged.

James McGregor of the Pontiac Machine & Foundry Co., Pontiac, Mich., recently purchased a site on which he plans to erect a new machine shop and foundry.

Lakomsky Bros., Dubois street and East Grand boulevard, Detroit, plans to erect a foundry, 120 x 150 feet. J. G. Kastler & Co., 523 Chamber of Commerce building, Detroit, are architects.

An iron foundry is to be established at the foot of Sullivan street, Brooklyn, N. Y., by the Pigot-Sayre Co., which recently purchased a plot of land there.

The Florence Iron Works, Florence, N. J., has resumed work in departments which have been closed for several weeks. The old foundry has also been put in operation.

The East Penn Foundry Co., Macungie, Pa., has been organized and will build a new plant. Among the incorporators is John G. Fleck, 50 North Fifth street, Philadelphia.

A modern foundry will be erected by the Penn Foundry Co., Johnstown, Pa. Present plans call for the erection of the building on Bridge street, Moxham, Pa.

A large plant addition is being erected at the plant of the Wheeling Mold & Foundry Co., Wheeling, W. Va. The building will be 300 x 350 feet. One part of the extension will be used as a pattern room.

Among the recent Texas incorporations is that of the Service Foundry Co., Beaumont, Tex., which is capitalized at $10,000. The incorporators are Thomas Grigsby, T. H. Marby and C. B. Marby.

The Altus Machine & Boiler Works, Altus, Okla., recently was established by C. T. Brunson, who has purchased a machine shop from Lucius Brunton and plans to add a foundry and other departments.

The Pullings-Long Co., Lima, O., is reported to have purchased the property of the Lima Steel Foundry and will engage in the manufacture of machinery.

The Marion Foundry Corp., Marion, Ind., has been organized and will build a plant. The company is capitalized at $30,000 and is headed by Ora E. Butz, George L. Cole, K. E. Morris and L. Leroy Close.

A patented reversible pipe joint will be added to the products manufactured by the Reading Foundry & Supply Co., 242 South Seventh street, Reading Pa. The joint recently was invented by George W. Kafer, Trenton, N. J.

Plans are being made to remove the plant of the Bronzo Alumina Corp., Tonawanda, N. Y., to Buffalo. The company's foundry recently was damaged by fire. J. H. Wilting, 327 Johnson street, Buffalo, is manager.

The Berlin Foundry & Machine Co., Berlin, N. H., closed bids March 31 for the construction of a foundry. The company plans to install a boring and turning mill with two swivel heads and an engine lathe equipped with quick-change gears.

Additional equipment, including a cupola, a mold conveyor and sand conveying equipment has been installed by the Ferro Machine & Foundry Co., Cleveland. This equipment is expected to be in operation by June 1.

Plans are being prepared by F. Savignano, architect, 6004 Fourteenth avenue, Brooklyn, N. Y., for the construction of a foundry, 60 x 100 feet, to be erected at Sixtieth and Twelfth avenues. The name of the owner has been withheld.

It is reported that Anderson & Mathison, Inc., Norfolk, O., recently incorporated, plans to establish a foundry and iron works here. The officers of the firm are A. N. Anderson, Bernard Mathison and Louis Ehrenworth.

The Bayley Mfg. Co., 732 Greenbush street, Milwaukee, recently increased its capital from $140,000 to $250,000. Some time ago the company had tentative plans prepared for a foundry, but no definite decision as to its construction has been made as yet.

Among the recent Delaware incorporations is that of the National Gear Wheel Foundry, Inc., Dover. The company will engage in a general foundry and machine shop business. It has been capitalized at $350,000.

F. R. Still is secretary of the American Blower Co., 1400 Russell avenue, Detroit, which recently purchased 20 acres as a site for a plant. The foundry will be the first unit built and construction of it will be undertaken shortly.

Plans are being prepared for the erection of an addition to the foundry of the Durbin Automatic Train Pipe Connector Co., East St. Louis, Ill., which will be 100 x 300 feet. V. G. Durbin is president of the company.

The Annex Foundry Co., Elkhart, Ind., gray iron and semi-steel castings, capitalized at $30,000, is building a plant, 60 x 168 feet and plans the construction of a similar building in the near future. The plant will be equipped with modern foundry equipment. T. A. Runyan is president.

The plant of the Ames Plow Co., Framingham, Mass., recently was acquired by the B. F. Sturtevant Co., Hyde Park, Boston, and plans to improve and remodel the plant as a foundry for the manufacture of brass castings, are being prepared. The building is 200 x 320 feet.

Notice of organization has been filed by the Columbia Brass Foundry, 722 High street, Los Angeles. The company will manufacture brass and bronze castings. C. L. Hawse, 3809 Third avenue and Joseph Kern, 1335 San Julian street, are officers of the company.

Plans are being completed for the erection of an addition to the iron and steel foundry of the United States Switch Co., Eau Claire, Wis. The company also plans to erect a machine shop addition. The company specializes in the manufacture of railway appliances.

The Southern Foundry & Machine Co., Chattanooga, Tenn., capital $75,000, has applied for a charter and purchased a site on which to erect a foundry. The incorporators are William Cummings, J. H. Anderson, T. P. Shepherd, E. H. Williams and W. J. Cottet.

The Reading Valve & Forgings Co., Reading, Pa., has been incorporated to manufacture castings and forgings with $100,000 capital. The incorporators are J. Turner Moore, Wyomissing, Pa., M. G. Moore and W. S. Dietrich. The company will build a plant shortly.

The Ventura Mfg. Co., Ventura, Cal., plans three buildings, a machine shop, 75 x 220 feet; forge shop, 75 x 220 feet, and an assembling plant, 50 x 220 feet. A foundry and pattern shop will be erected later. W. J. Saunders, Laughlin building, is architect.

A recent Connecticut incorporation is that of the Derby Brass Foundry, which has been capitalized at $2500. The company will engage in the manufacture of brass castings, etc. Among the incorporators are George W. Castle, Joseph O'Connor and David L. McDermott. The company will locate in Derby, Conn.

A recent New Jersey incorporation is that of the Cameron Iron & Bronze Co., New Brunswick, N. J., which has been incorporated with $30,000 capital. The company will manufacture iron and bronze castings, fences and fixtures. The incorporators are Margaret A. Harkins and Helen C. Barnwell, Highland Park, N. J., and William P. Danberry, New Brunswick.

The plant of the Frantz-Premier Co., Ivanhoe road, East Cleveland, O., recently was taken over by the Electric Vacuum Cleaner Co., which is affiliated with the General Electric Co., Schenectady, N. Y. At present this plant consists of three units, a foundry, a power house and a 4-story factory building, but according to a report the capacity of the plant will be greatly enlarged, to enable the company to enlarge the plant's present output.

NEW TRADE PUBLICATIONS

STRUCTURE MOVING.—An attractive and well illustrated 56-page booklet of pocket size, has been published by the John Eichleay Jr., Co., Pittsburgh, illustrating the methods of this company in moving large structures. Illustrations show raising, moving and lowering structures of all kinds, including mill and office buildings, churches, stores, schools, dwellings, bridges, blast furnaces, car unloaders, tanks, boats, machinery, boilers and engines. One illustration shows hot blast stove, hoist and blast pipes at the New Castle, Pa., plant of the Carnegie Steel Co., being raised 21 feet. The total weight of the load was 1100 tons.

CIRCUIT BREAKERS.—An interesting booklet has been issued by the Roller-Smith Co., New York, describing and illustrating a circuit breaker for industrial service. This breaker can be furnished for wall mounting. The range of adjustment is from normal rating to twice normal rating. The calibration scale is in plain view and can easily be reset. The booklet gives complete specifications and data.

REGISTERING DEVICES.—A 4-page bulletin describing direct-current voltmeters and ammeters has been issued by the Roller-Smith Co., New York. These are suitable for use for small switchboards, battery charging outfits, and other equipment requiring small instruments. They all are enclosed in brass casings, 4 inches in diameter. One page of the booklet is devoted to specifications.

PERFORATED METALS.—The Hendrick Mfg. Co., Carbondale, Pa., has issued a 127-page, illustrated catalog, in which the company's perforated metal products are described and illustrated. The first section of the booklet is devoted to the description of perforated metal screen plates. This is followed by a portion devoted to screens for the separation and cleaning of coal, coke, stone, clay, and other bulk materials. There are various models of these screens illustrated. Other equipment described, includes shaking screens, revolving screens, screens for cement and ore, locomotive screens, metal guards, metal spark arresters, elevator buckets, stacks, hoppers and elevator casings, hoppers, loading chutes and various other equipment. Specifications and other data are given.

WELDING AND CUTTING APPARATUS.—The Air Reduction Co., New York, has prepared two interesting pamphlets outlining special jobs on which welding and cutting apparatus was used. In the first is described a worn switch frog which was built-up by welding. The cost analysis in this case shows a direct expense of less than $10 for the repair. The second leaflet illustrates the welding with patterns of a locomotive cylinder which was badly damaged in a collision on the Lake Erie & Western railroad.

COMPRESSORS. — The Norwalk Iron Works Co., South Norwalk, Conn., has published a 16-page bulletin describing its compressors for oxygen and hydrogen. Points of design developed to attain high speed, with light weight, and compact but accessible construction are outlined. The compressors shown vary in capacity from a displacement of 12 to 196 cubic feet per minute. The cooling system used, embodying water-jacketed cylinders and special intercoolers is described and illustrated. The intercoolers divide the gas from the first cylinder into a series of thin streams which pass around pipes in which water is circulating. All details of construction even to the method of bearing adjustment and packing of joints are outlined in this bulletin.

PNEUMATIC TOOLS.—The Independent Pneumatic Tool Co., Chicago, has prepared a circular describing a variety of tools which it manufactures. Simple and compound piston air drills, turbine air drills, wood-boring machines, bench and floor molders' rammers, riveting hammers, pneumatic holder-on tools, air grinders, and pneumatic hoists all are illustrated. Complete specifications for its entire line of pneumatic hammers, drills, rammers and other tools are given in this circular.

CRANES.—Traveling cranes are described and illustrated in a catalog recently issued by the Milwaukee Electric Crane & Mfg. Co., Milwaukee. The catalog is well illustrated and shows several shop and yard installations as well as details of construction. All bridge end trucks, it is explained, are structural steel fitted with cast steel brackets so designed that the load is evenly divided and distortion thereby avoided. All gears are steel, and are enclosed in oil-tight cases. An interesting feature of this crane is a hoisting limit switch which is designed to prevent over-hoisting. When the book reaches its highest safe position the hoist motor line is automatically opened.

MOTOR FUSE TABLES.—The Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has prepared an elaborate set of tables showing the proper sizes of fuses to be used with motors of various types and horsepower. Each motor's normal operating current is given by the maker on the nameplate, but the fuses should have a larger capacity to allow for starting current and for momentary overloads. For instance, a polyphase wound-rotor type motor uses 1.25 times the full-load current when starting. A squirrel cage motor, when thrown on the line, uses three times its full-load rating; a single-phase repulsion induction motor absorbs twice its normal current when starting with a rheostat and four times when not fitted with a rheostat. A direct-current motor takes 1.25 times its normal current in starting. These overloads must be borne in mind when selecting fuses if trouble resulting from fuses burning out unnecessarily is to be avoided. The tables prepared by the Westinghouse company take these factors into account. At the same time an effort has been made to proportion the fuses so that they will afford proper protection to the motor.